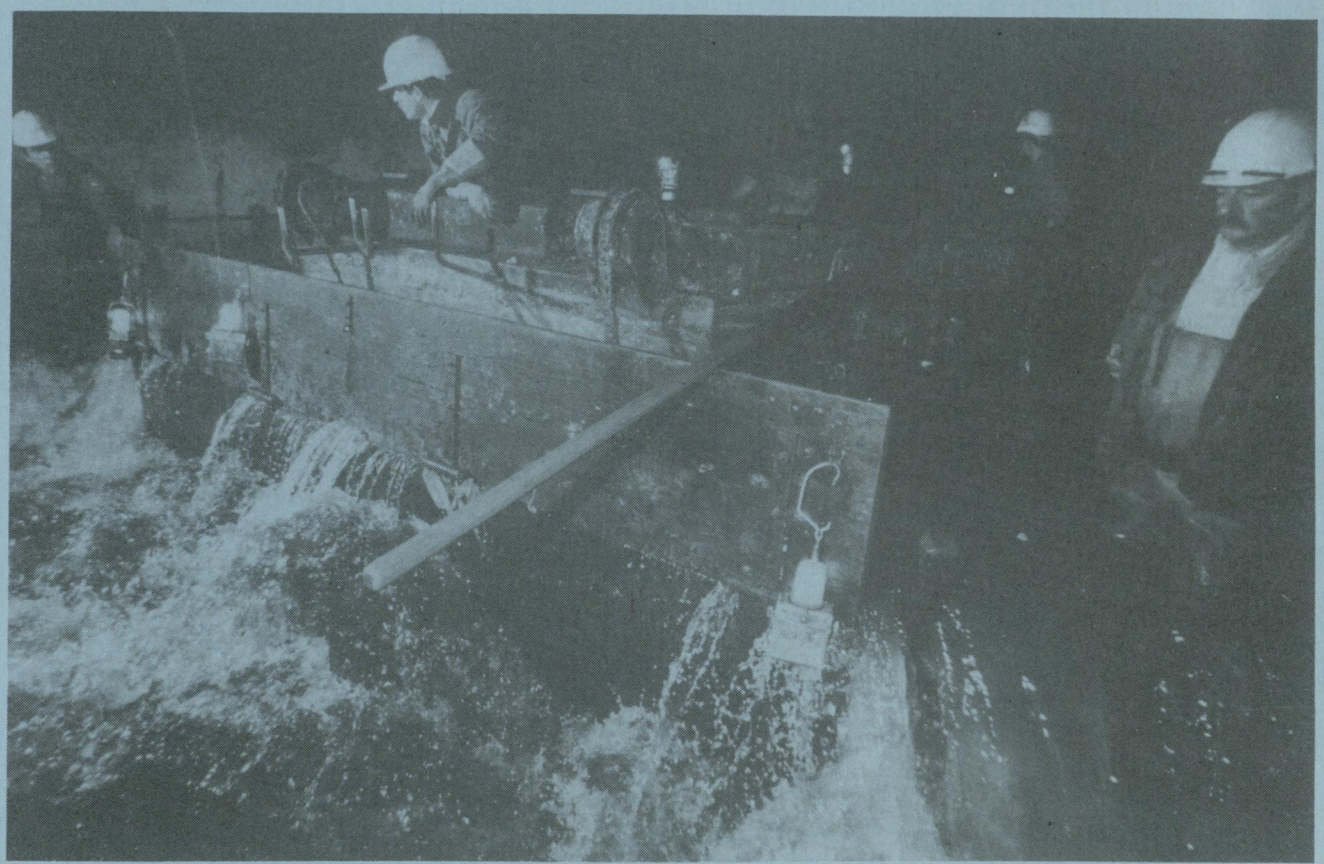
ISSN No 0307 1650

SUBTERRANEA BRITANNICA



Bulletin 30

THE BULLETIN OF SUBTERRANEA BRITANNICA

No. 30 – Winter 1994.

CONTENTS

Editorial

I do hope that you enjoy reading this *Bulletin*. We have continued the series of papers given at the International Conference at Bath and, wherever possible, I have included French and German abstracts of these papers for the benefit of foreign readers. (Don't let me catch anybody calling me a xenophobe!). The Czech diacritical marks and Icelandic characters have been a real challenge to my Macintosh. There has been more than enough copy to fill this issue, even though we have increased the number of pages, so some papers have been held over to *Bulletin 31*; I apologise to readers and especially to the authors for this delay in publication.

This is the first and last editorial that I shall write as Editor of the *Bulletin*; at a Committee meeting last year, I agreed to publish this issue as there was nobody else willing to take on the job. So this editorial is really a **"Situations Vacant"** column as I am unable to produce the next issue. However, I will be more than happy to offer whatever help I can, as will Sylvia and Malcolm (who have edited issues in the past) and the rest of the Committee. If you are interested in finding out what is involved, please do not hesitate to telephone one of the people listed below; although the job is unpaid, all (reasonable) expenses will be met.

Subterranea Britannica is associated with *Société Française d'Etude des Souterrains* of France, *Arbeitskreis für Erdstallforschung* of Germany, *SOBERES* of Belgium and *Studiegroep Onderaardse Kalksteengroeven (SOK)* of Netherlands.

The Bulletin is the official publication of Subterranea Britannica. This issue has been compiled by M C Black with invaluable assistance from Sylvia P Beamon, Malcolm Tadd, Paul Sowan, Gordon Allen and Bernard O'Connor.

Cover Photo: *Bateau-vanne* (gate-boat) flushing Clichy collector (see *The Paris Sewers*)

Underground Farming

Emmanuel Gaffard

SUMMARY
Among various re-uses of underground space in France, especially in stone quarries and mines, underground farming is significant. The slide show presented a few examples of underground cultivation taking place in France; mostly of mushrooms, and also of other less usual cultures, either traditional or experimental, both facing an uncertain future.

LES CULTURES SOUTERRAINES
Parmi les nombreuses possibilites de reutilisation des espaces souterrains, et en particulier des anciennes carrieres, l'agriculture souterraine occupe une place importante. Le diaporama presente quelques unes des cultures souterraines pratiquees en France: la plus repandue, celle du champignon de Paris, mais aussi des cultures plus rares, traditionnelles ou au contraire encore experimentales, a l'avenir plus incertain.

AGRARWIRTSCHAFTLICHE NUTZUNG DES UNTERGRUNDS
Neben vielen anderen Wiederbenutzungsmoglich-keiten von Raum Untertage, z. B. in der Form von Unterageabbau von Naturschatzen, ist die agrarwirtschaftliche Kulturen im Untergrund in Frankreich, zumeist Champignions oder andere seltene Kulturen, entweder aus langer Tradition oder immernoch im experimentellen Stadium. Ihnen gleich ist aber eine ungewisse Zukunft.

UNDERGROUND FARMING

The numerous instances of re-use of underground quarries and stone mines in France for farming illustrate the benefits of protected sites. Indeed, agriculture being a rather low-profit activity, the farmer does not usually have the means to make large installations which, however desirable they may be for comfort and safety, appear to quarry enthusiasts as damage. Conversely, the underground surroundings provide famers with often ideal climatic conditions (12 to 16°C; 85 to 90% relative humidity), as well as protection against most hazards of cultivation in the open. The cultivated mushroom (literally from French 'Paris mushroom') probably requires the least improvement upon the underground environment, which is why it makes up by itself most instances of underground farming. This non-exhaustive account was a photographic presentation of some types of underground farming in France.

A- Fungi

I - The 'Paris mushroom'

a - Brief history

The first underground growers of the 'Paris mushroom' settled to work in the former quarries to the south of Paris around 1812. Until then, and for at least two centuries, this cultivation had been carried on in the open.

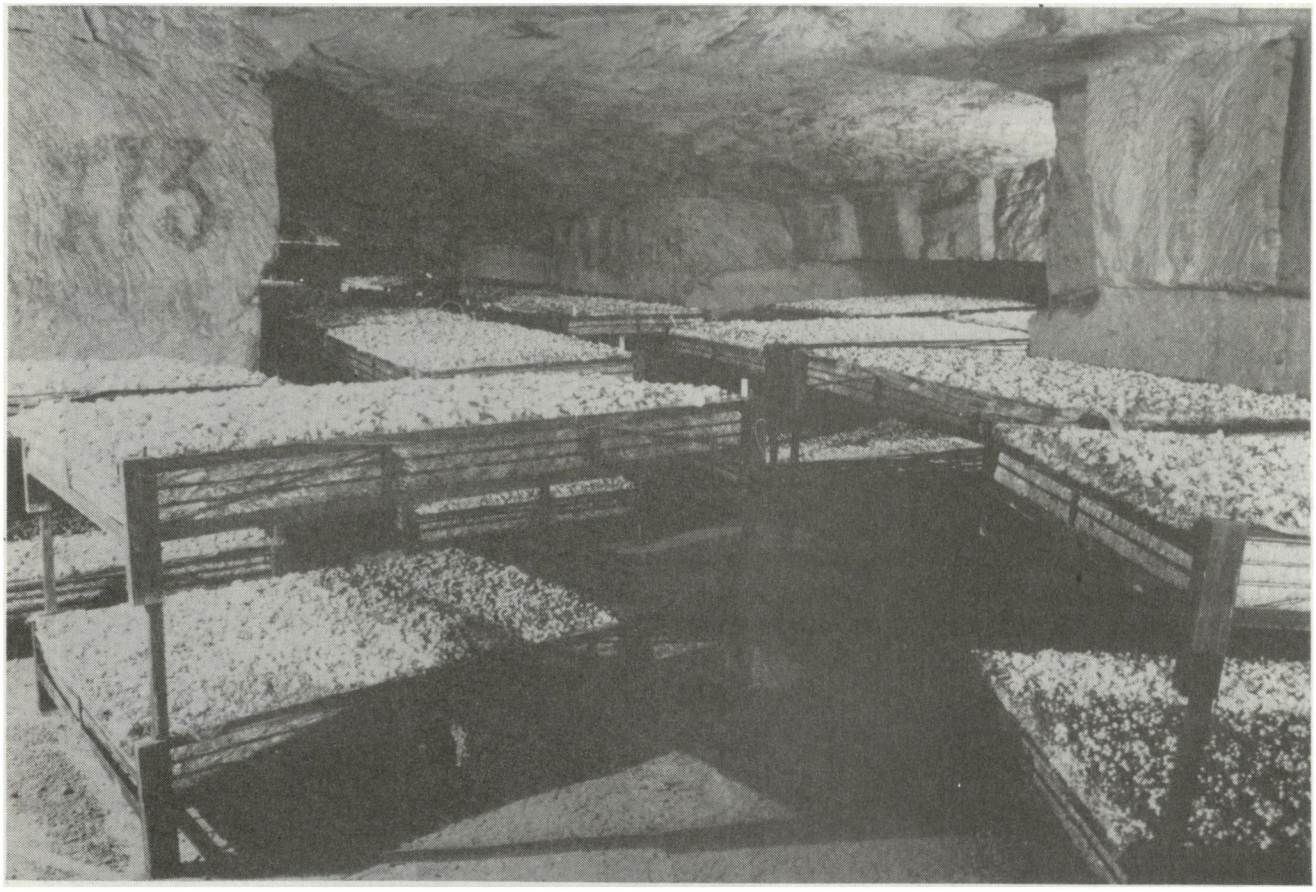
The traditional method, which was used until the 1960s, was cultivation *'en meules'*, literally 'in heaps.' The grower obtained horse manure, which was brought to the right degree of fermentation outside the quarry. The 'heaps' were then raised by hand inside the quarry, which had first been thoroughly disinfected. Then, during the *'lardage'*, the 'heaps' were seeded with mushroom spawn (*'blanc de champignon'*), usually procured from specialists. Afterwards, the 'heaps' were covered with sterile soil (quarry spoil in the form of fine rock dust); that operation was called *'gobetage'* (the equivalent English term is 'casing.')

After three to four weeks of waiting and watering, the first mushrooms would appear (*'premiere volee'*); picking would go on for eight to 12 weeks, along with more watering. The then exhausted 'heaps' were then dismantled, and the ground cleared and sterilized again.

b - Present-day situation

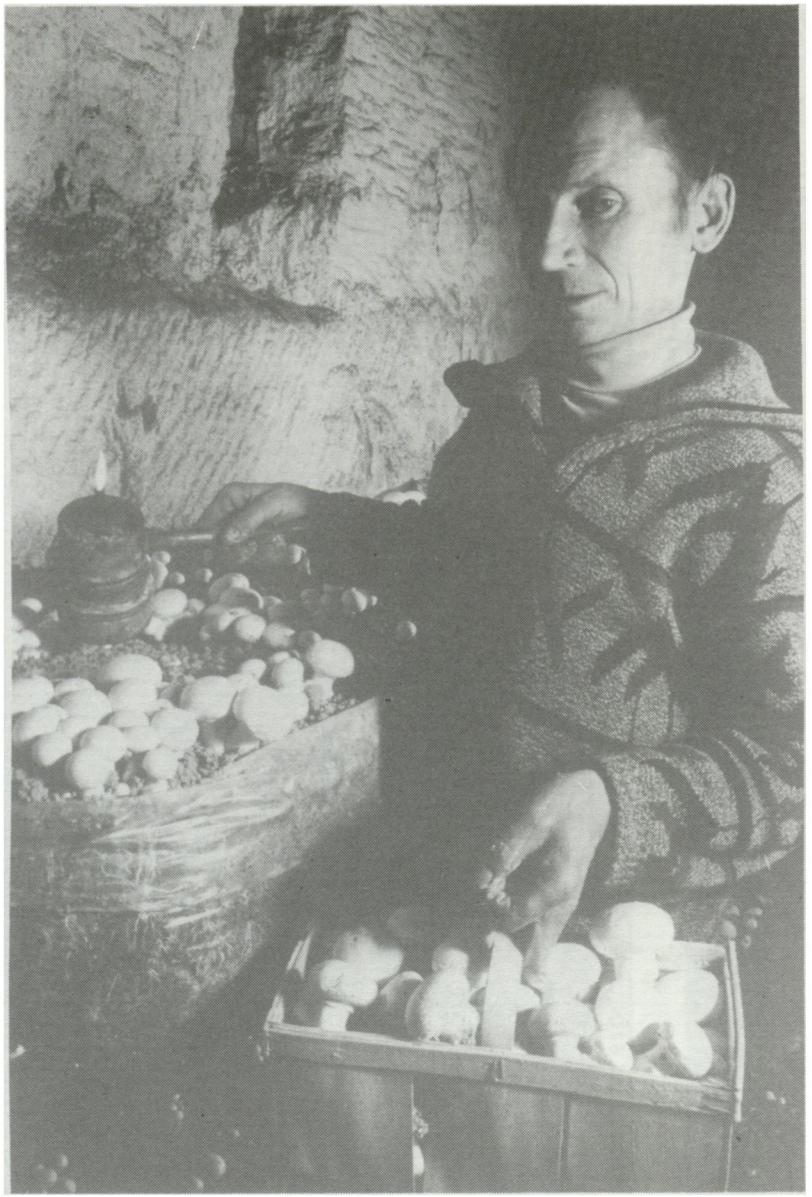
1 - The Paris district

The Parisian growers have relinquished the narrow quarry galleries nearest to central Paris. They have moved to the suburbs and further, into medium-sized galleries wide and high enough for convenience but not too large, so that the air volume remains reasonable. Indeed, ventilation must be strictly controlled through the use of air shafts, ventilators, and bratticing.

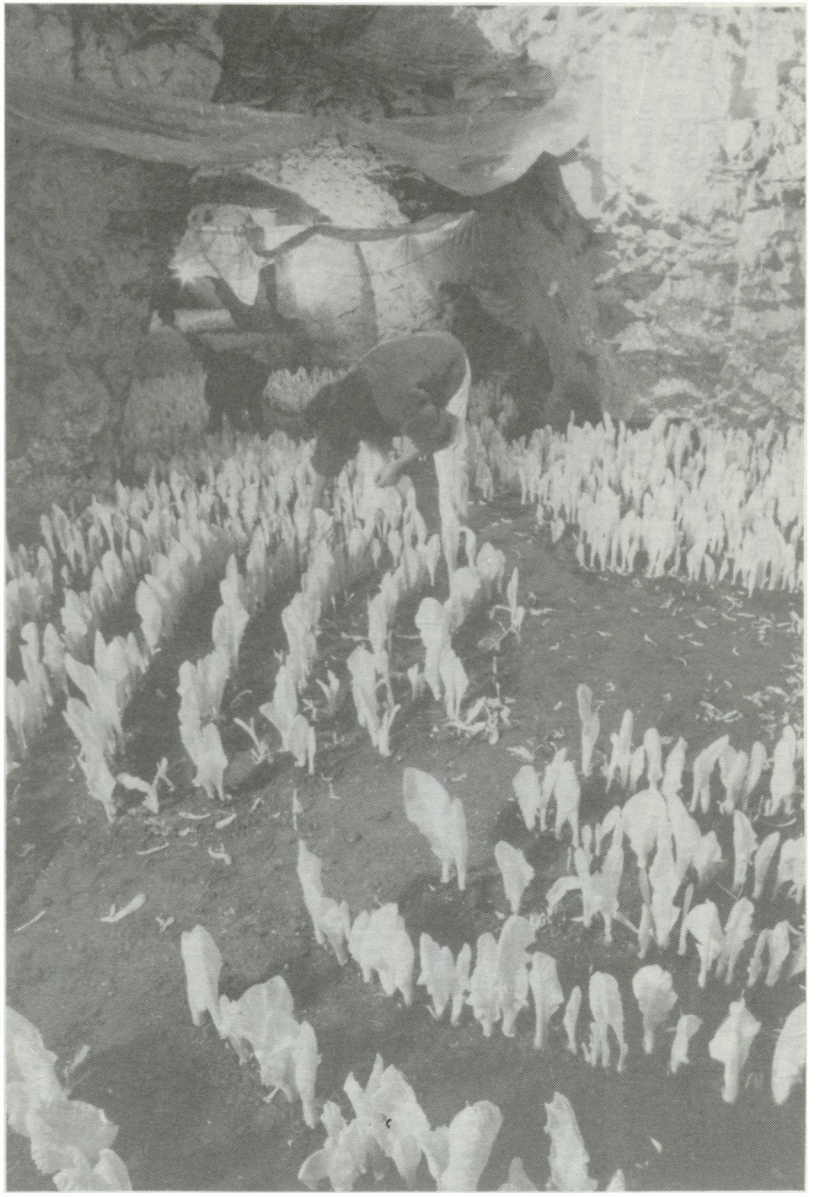


Top: *Early 20th century mushroom bed; heap growing, in a chalk pit near Paris. Notice oil lamps with handles.*

Bottom: *Modern mushroom bed in Bourré (Loir-et-Cher, Loire Rive district); crate growing.*



White Paris mushroom in Carrières-sur-Seine (Yvelines); sack growing; acetylene lamp with handle.



Picking "Capuchin's Beard" in Loos (Nord).

Nevertheless, a few growers still use the huge gypsum mines in the north-eastern suburbs, to be precise Livry-Gargan, and Gagny, Seine-St-Denis. Galleries here are as high as 18 metres, and mushroom pickers choose to wear helmets!

The 'heaps' method has given way to growing in polythene sacks for more than 20 years. The ready-to-use sacks offer easier handling, and a lower risk of contamination. The main stages remain the same - *'lardage'* (spawning), *'gobetage'* (casing), watering, growing, picking, and sterilising in readiness for the next crop. However, the discarded sacks prove impossible to recycle, as manure cannot be separated from plastic at a reasonable cost. Consequently, this technique is being given up, because of stricter environmental regulations.

2 - The Loire district

The areas neighbouring the Loire river have long been undermined. Many under-ground quarries, mines, cave-dwellings, and of course mushroom beds can be found. This is the premier district of France in terms of mushroom production.'Sack' growing is employed here, as well a cultivation in wooden cases and, mainly, metal crates. In the latter, handling is even further reduced: picking may be faster, but remains uncomfortable!

3 - Other types of underground locations

Let us briefly indicate a few of the stranger locations used for mushroom cultivation - a former railway tunnel at St. Raphael (Var, in the south of France); underground passages in the defence works at Neuf-Brisach (Haut-Rhin, Alsace); and also a former German military hospital in Jersey (Great Britain.)

II - Other fungi

Cultivation of rarer, more difficult fungi has been tried for a long time. Morels, for instance: a few people must be secretly, but probably not very successfully, attempting to grow them. Two varieties, at least, seem possible (if not profitable) for underground cultivation - *'pleurotte'* and *'shii-take'*.

a - *Pleurotte*

'Pleurotte' (untranslatable) is grown on fermented straw stacks. It is not watered, but requires eight hours of light every day, and three times more air than the 'Paris mushroom.' Ventilation must be strong, and temperatures as low as below 10° C are required.

b - *Shii-take*

'Shii-take' is a fungus of Japanese origin. It sells for a high price, but is not easy to grow. It is a slow crop: the straw stacks bear fungi for one year. They must be watered every two days, lit eight hours each day, and also kept at 18°C, so the quarry must be heated. In fact it is not unusual for ordinary mushroom growers to heat their quarries to raise production.

Cultivation of both *'pleurotte'* and *'shii-take'* is difficult, and cheaper imports of the first, from eastern Europe, and technical difficulties with the second tend to make this cultivation uneconomic. Indeed, at Cuts (Oise, north of Paris), the growers have reverted to cultivating the 'Paris mushroom.'

B - Other Plants

I - Various

Since it is possible to light underground quarries for some fungus crops, then why not grow other kinds of photo-synthesising plants? Indeed, at Parmain (Val-d'Oise, outermost Paris suburbs), tulips are cultivated all year round in an underground quarry!

II - Endive

Sometimes, however, darkness is necessary to certain stages of successful cultivation - for instance, in the case of chicory (in French, *'endive'*.) Darkness permits tender white sprouts or leaves to grow, whereas the green leaves that develop in daylight are considered inedible. The plant is sown in open fields in Spring, and soon sprouts unusable green leaves which are discarded. In the Autumn, the roots or 'carrots' are picked and placed in a forcing house, usually a dark ground-level greenhouse. Merely close-packed in a case, they the produce the edible whitish sprouts. The quarry at Parmain, already mentioned, is also used as a forcing-house. Similar cultivation takes place in Belgium and the Netherlands, where the crop is called *'witlof'*.

III - *'Capuchin's beard'*

'Capuchin's beard', a kind of wild endive (French *'chicoree'*), is a traditional native crop from the north of France. In the town of Loos, a suburn of Lille (Nord), there can be found the last five growers of this winter salad, which was introduced from Belgium in the 1860s. These growers have settled in the quarries of this area, called *'catiches'*. The word *'catiche'* actually applies to the stonework 'plugs' used to seal the extraction shafts to the quarry chambers. Cultivation methods are similar to those used for

chicory, but in this case the 'carrots' are laid on the ground and slightly covered. Watered frequently, they give five to six harvests of large yellow-white leaves throughout the winter, about every 14 days. Unlike chicory, the leaves are allowed to grow to their full size. Access to these quarries is by way of the former extraction shafts - in fact the crop is grown in an underground chamber without the sealing *'catiche'*. Hand-cranked windlasses, similar to those formerly used by the quarrymen, are used to raise goods. It is, unfortunately, probable that this cultivation will disappear from France with the last of the present farmers.

C - Miscellany

Among agricultural activities that could, at least partially, relate to underground farming, should be noticed (all in underground quarries):

- rhubarb growing, in Kanne (Belgium), in 1985;
- barley germination in Faches-Thumesnil (Nord, France), around 1935;
- the maturing of bananas (place and date unknown);
- onion 'growing' in Genainville (Val-d'Oise, France), currently;
- vegetable storage during winter in the Carrieres-sous-Bois (Yvelines, France), offering cost-free protection from frost for beetroots, turnips, etc;

However, the underground locations for these activities probably simply reflect the coincidental presence of quarries, near the main centres of activity.

Conclusion

One must remember that only the 'Paris mushroom' is cultivated on a large scale. All other underground farming seems to be either on its way out, or facing dificulties becoming efficient.

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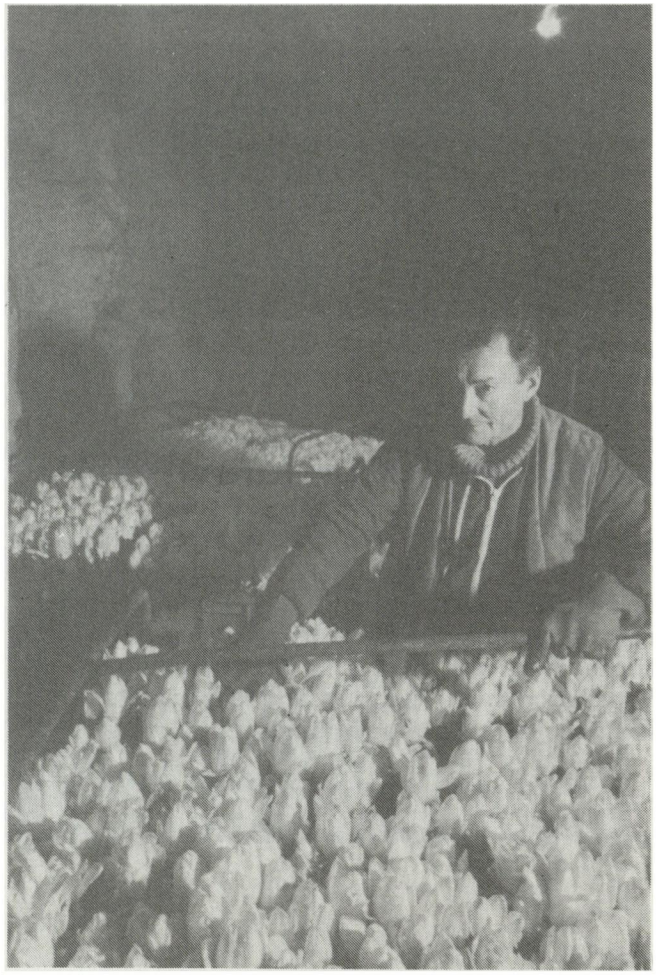


Forcing chicory in Parmain (Val-d'Oise)

The Paris Sewers

Emmanuel Gaffard

The Paris sewerage system was almost entirely conceived and built during the 19th century. Despite the daring and insight of the designer (Eugene Belgrand), the system has become outdated and inefficient in terms of cleansing, safety, etc., as a result of official neglect. A slide show presented the structure of this, in some ways, unique network; the consequences of yesterday's decisions on today's sewerage; and some necessary improvements.

LES EGOUTS DE PARIS
Le reseau d'egouts parisien fut concu et construit presque entierement au 19e siecle. Si son createur, l'ingenieur Belgrand, fit preuve d'audace et de lucidite, force est de constater que son ouvrage, n'ayant que peu evolue depuis, est devenu depasse, sur des points aujourd'hui essentiels: qualite, de l'epuration, conditions de travail du personnel etc. . . . L'auteur presente a travers un diaporama, la structure de ce reseau par certains cotes unique au monde, les consequences des choix du 19e siecle sur l'assainissement actuel de Paris, et les indispensables modernisations profondes qui se font jour.

DAS PARISER ABWASSERSYSTEM
Das Pariser Kanalisationssytem wurde fast ausschliesslich im 19 Jahrhundert entwickelt und gebaut. Obwohl der Erfinder Eugene Belgrand fur seine Zeit aussergewohnliches Einfuhlungsvermogen und technischen Vorausblick bewies, sind heute viele Konstruktionen, vor allem aus Mangel an technischer Weiterentwicklung in den vergangenen Jahrzehnten, uberholt. Dies gilt insbesondere fur die Effektivitat des Abwasser-systems, als auch fur die Sicherheit der Arbeiter um nur einige Beispiele zu nennen. Der Diavortrag zeigt die Struktur des, auf mannigfaltige Art einmaligen Kanalisationssytems; die Auswirkungen der Entscheidungen von gestern auf das Abwassersystem von heute und notwendige Verbesserungen.

Though often unrecognized, the sewerage systems of large towns are outstanding examples of 'artificial cavities.' They allow the bringing together of considerations about the history of public hygiene, about daring engineering works, and the more acute environmental reflections. What follows describes the Paris sewer system, one of Europe's first in modern times.

A - History and Structure

I - Belgrand's revolution

Modern sewerage in Paris appeared during the 19th century, with the sudden awareness that foul water, and not air, is responsible for the spreading of contagious diseases (mostly cholera, which threatened and affected Paris and all Europe throughout the century.) This medical revolution was soon followed by audacious administrative decisions: in 1854, Baron Haussmann, prefect of Paris, commissioned Chief-Engineer Eugene Belgrand with the simultaneous building of a drinking-water supply system (very inadequate until then), and a sewer system (drastically insufficient.) Truly, a few forebears had attempted to improve on this situation. In 1700, the Paris sewers totalled 11 kilometres, only 3 kilometres of which were covered! On the day of Belgrand's arrival, they amounted to 163 kilometres. But around 1900, the total length reached 1,000 kilometres, having increased tenfold in only 60 years! Today, 2,100 kilometres of sewers run beneath the Paris streets.

II - Basic principles

It is, then, under Belgrand's guidance that the basic principles for the new system were decided; they are still of great consequence to this day. They are as follows:

- the system would be entirely visitable;
- The ovoid profile (imported from London, and adopted as early as 1851) would be continued, as it permits drastic cost reductions;
- the system would be gravity-operated, the water flowing naturally down the slopes of the ducts (some exceptions to this rule are found in the lowest-lying neighbour-hoods);
- the sewage transit through the system would be as fast as possible (to avoid septic fermentation) towards a unique outlet into the Seine at Clichy;
- predominantly, only rainwater and runnoff from streets would be admitted to the sewer network; foul water (containing excrement) was to be collected in cesspits under

individual houses, and carried by road to dumps.

This last point, enforced by Haussmann himself (against the better judgement of his engineers), would prove later to be one of his few mistakes. Indeed, in 1894 there was enacted a law relating to sewage disposal (requiring, literally, 'all-to-the-sewer') which then made it compulsory to direct all water to the system. The system thenceforth was a unitary one, and direct discharge to the river was abandoned.

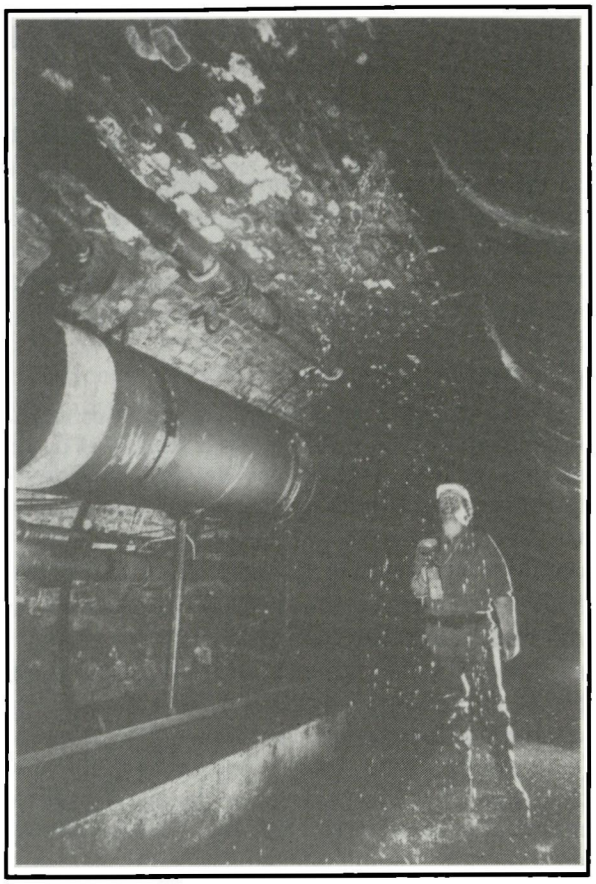
III - Types of works

The network is divided into three main categories of sewers: the smallest 'elementary' sewers; then the medium-sized sewers (secondary collectors) receiving sewage from particular neigbourhoods; and finally the main sewers (primary collectors) to bring the water to its destination. Nowadays, the sewage is carried away from this point, as well as from various suburban districts, to a sewage treatment plant, by way of newer 'emissaries' (super-collectors.) These large, non-visitable works, of from two to four metres diameter, reproduce on a larger scale Belgrand's network of primary collectors.

Right from the beginning, it was planned to use the sewer galleries as passages for fresh drinking-water supply pipes. For instance, the Sebastopol collector, a secondary for its sewage flow, was given the proportions of a primary to make room for two water mains.

A few special works completed the network: syphons for under-river crossings, and (mainly) stormwater overflow outlets. In case of very high rainfall, the sewers might not be able to conduct the entire volume out of the City, resulting in untreated water flooding into the streets, which is not acceptable. Therefore, surplus untreated (but, in the circumstances, significantly diluted) stormwater can be directed straight into the Seine. This is possible throughout the network, mainly near the river, although some stormwater overflow routes can be very long, serving the most outlying areas.

Here we come to the most serious consequence of the system's unitary nature: such rejected water is extremely polluted, and in really bad storms tens of tonnes of fish die of asphyxiation. Overflow can also happen if a primary collector has to be serviced. Consequently, the beds of most primary collectors have never been inspected since they were built! In the event of abnormally high water levels in the Seine, the overflow outlets automatically close. If at such times there is a storm, special pumping stations raise the sewer water to a sufficiently high level



The Sébastopol collector, with its two water mains

before discharging it to the river. Permanently operating plants of this kind, moreover, raise the sewage from the lowest-lying areas before sending it into the collectors. These can raise sewage from 0.97 metres (Usine de Mazas, Paris 12e) to as much as 37 metres (Usine de Pierrelaye, Val-d'Oise, along the 'emissary' to the sewage farms.)

B - The Work of the Sewermen

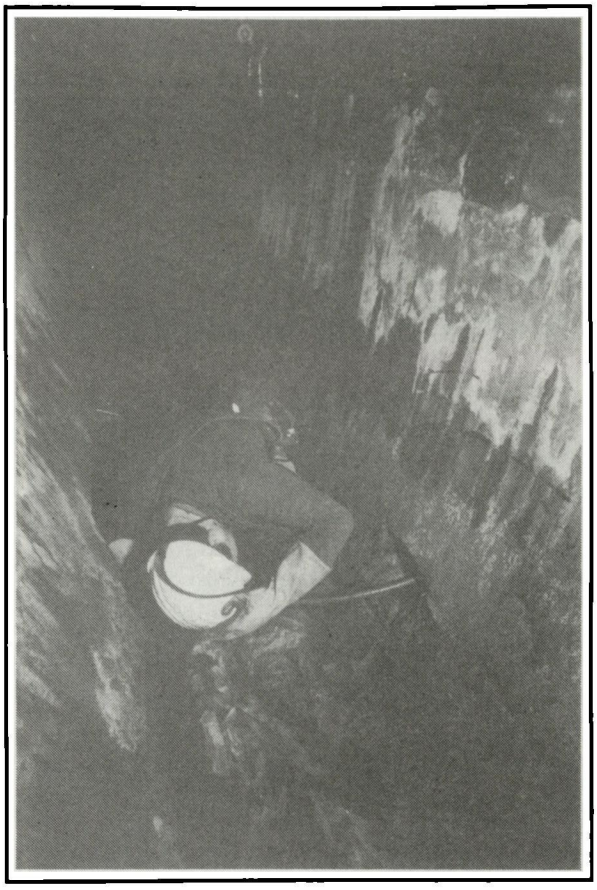
I - Flushing

It is the duty of the 500 sewer-men to maintain the system's condition. Mostly, they take care of the flushing of sediment that collects in the sewers. The implements used in this operation are exactly those devised by Eugene Belgrand 130 years ago. Entirely passive by themselves, they rely on the force exerted by the water. They consist of 'mobile floodgates', raising the sewage level upstream and thus raising the pressure at the bottom of the sewer. Then the gate is opened a little, water rushes through, and the increased velocity flushes away the sediment.

The smaller item used in the elementary sewers is a hand-held machine, *'la mitrailleuse'* ('the

sub-machine-gun.') In secondary collectors, a *'wagon vanne'* (literally, 'gate-carriage') is used, travelling on the angles of the footpaths alongside the underground waterways. This moves forward by itself, pushed from behind by the water pressure, and keeping sediment ahead of it. The equivalent device in the primaries is the *'bateau-vanne'* (or 'gate-boat'), a free-floating instrument, the handling of which is impressive (see cover photograph), but not without risk.

The non-visitable syphons and emissaries are flushed by means of a wooden ball, slightly narrower than the duct, that rolls along on the top of the pipe as it tries to float. Water speed at he bottom is thus increased and, again, sediment is flushed forward.



Clearing a private junction in an elementary sewer

'Sediment catch pits' are built at intervals along all collectors, where sediment accumulates as a result of the operation of the devices described. These pits must be cleaned out regularly, either by mechanical shovels, or by suction dredgers. This arduous operation is usually entrusted to sub-contractors to whom, apparently, the strict safety regulations for the City of Paris sewermen do not apply.

Let us briefly mention a modern method, replacing flushing, successfully experimented on in an exceedingly clogged section of the Clichy primary collector. This active (self-propelled) machine did in four months what would not have been achieved in ten years of cleaning by traditional methods - whilst maintaining the collector in full operation.

II - Risk

Apart from the obvious dangers of using the outdated flushing devices described, the main risks to which the sewermen are exposed are:

- drowning (equipment and water-filled boots can be very heavy, and the current very fast);
- leptospirosis or Weil's disease (a disease transmitted via rats' urine, sometimes mortal: sewermen are now vaccinated against it);
- toxic and explosive gases (mainly hydrogen sulphide: the discharge of toxic wastes into the sewers, though strictly prohibited, is not uncommon);
- lastly, the hazard of a sudden rise in water level following heavy rainfall (guarded against by the required permanent presence of a 'surface man' at the nearest manhole, who can warn his colleagues in good time.)

C - Sewage Treatment

Let us now follow this underground stream away from the City, to the treatment sites.

I - Sewage farms

The first cleansing method used was sewage farming, an idea of (so it is said) Victor Hugo. From 1899 onwards this technique, using the cleansing capability of soil bacteria, permitted the processing of all the Paris sewage. The first 'emissary', 28 kilometres long and going via three pumping stations (Clichy, Colombes, and Pierrelaye), brought the sewage to the farm's 5,000 hectares. Today though, sewage farms have declined to a total area of 2,000 hectares, representing no more than a minor part (300,000 cubic metres per day in summer) of the 2,700,000 cubic metres of dry-weather Paris sewage each day.

II - The Acheres sewage treatment plant

As early as 1927, the predictable insufficiency of the sewage farms led to the planning of an enormous plant, in Acheres (Yvelines, downstream and west of Paris.) It is supplied by five large 'emissaries', the fifth of which is presently under construction. Four sections of

the plant have already been built, following a population increase. The fifth and last, planned to open in 1992, that would have brought the total capacity to those very 2,700,000 cubic metres per day, has been cancelled, to the benefit of various smaller plants upstream (two of which, at Noisy-le-Grand and Valenton (Val-de-Marne, east of Paris)), already help processing part of this area's sewage, avoiding its long transfer to Acheres.

So far, in dry weather, around 600,000 cubic metres per day are still rejected uncleansed; and much more in case of high rainfall.

Cleansing results from four stages. After a rough first treatment, during which floating detritus, sediment, and greases are removed, the water goes through a primary decantation, depositing finer suspended particles. Then, aerobic bacteria take care of the dissolved organic pollution in an aerator: this is known as the 'activated sludge' process. The sludge finally is deposited during a second decantation, after which the water is considered to be clean enough to be returned to the river.

The solid sludge is partly recycled through the aeration plant, and the excess is 'digested' by anaerobic bacteria in reactors and then dried and stored for sale.

It must be noticed that only the 'carbonic', or organic, pollution and the suspended solid particles are removed. Nitrogenous pollution (nitrates, ammonia), as well as rainwater pollution resulting from street washing (heavy metals, carbohydrates, sulphur compounds), are not retained. Once again, this problem is worsened by the unitary nature of the system, as separate pollutions would be easier to process. Nevertheless, prototypes for the processing of nitrogenous pollution exist and work on a small scale; adaptation to Acheres is proposed, but will be long and costly.

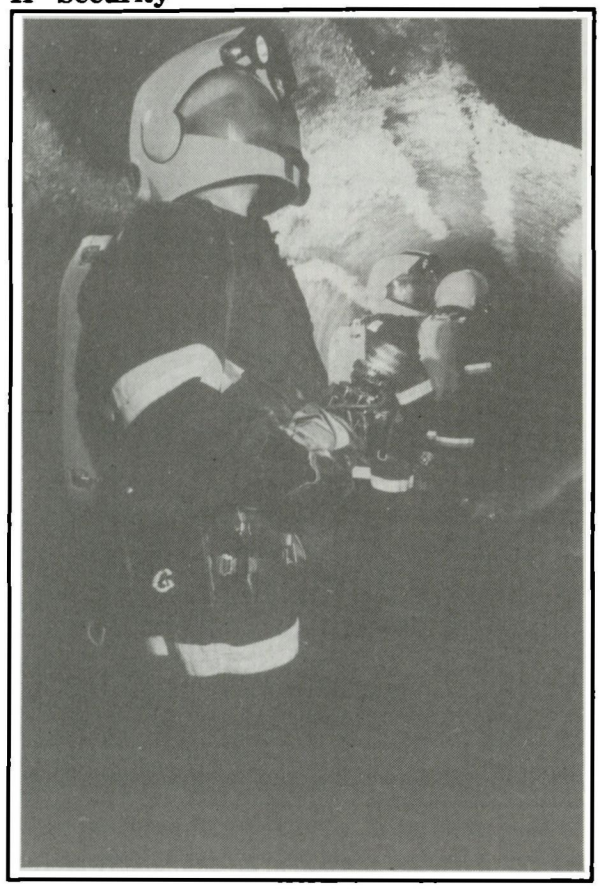
D - The Future: The Example of the Seine-St-Denis Departement

I - 'Flow management' capability

The future in French sewage systems lies north-east of Paris, in the neighbouring 'departement' of Seine-St-Denis. This district, not favoured by geography (former swampy areas, few or shallow slopes, natural outlets only at the borders, and rapid city growth), has been plagued in the past by recurrent dramatic floods. This situation and, maybe, also political competition with Paris, resulted in a drastic plan for complete modernization and optimisation of the existing network. Most importantly, a centralized, computerized flow management system was introduced, successfully representing enormous investment in new works (collectors, retaining pools, etc), classically operated.

The computer takes information from sensors all over the network (indicating water level and flow, as well as the condition of control devices), and weather predictions for rain (a few hours in advance.) From this data it computes, either automatically or under human guidance, the best configuration to adopt, and enforces it by means of its exclusive flow control devices (air intake syphons, inflatable dams - two inventions of this departement.) The network, being partly separative, includes retaining pools (storm tanks) for better control of rainwater,

II - Security



Seine-St-Denis sewermen's new safety gear.

The other feature of modernisation in this department, is workers' security. The main item is a prototype of new safety gear, soon to be in general use. It is a drowning-proof, watertight, floating contraption, including a helmet with incorporated gas sensor (automatically closing the vizor in case of a dangerous atmosphere), and air tank; it incorporates a two-way radio, connected to the main departement radio

network; and, lastly, a device by which the sewerman will be able to fasten himself to a safety rail, to be set up in dangerous spots.

Additionally, the flushing operations described in Paris have entirely been substituted by 'simple' pumping from the surface. The City of Paris, not wishing to stay behind, has introduced its own flow management system; but this functions only in the 'emissaries.'

Conclusion

The Paris sewerage system bears the obvious mark of the bold innovations of Chief-Engineer Belgrand. Nevertheless, the historical reversal of the 'all-to-the-sewer' law (though necessary), and the (relative) conservatism of 20th century managers, have contributed to let this brilliant network become insufficient, though by far not obsolete.

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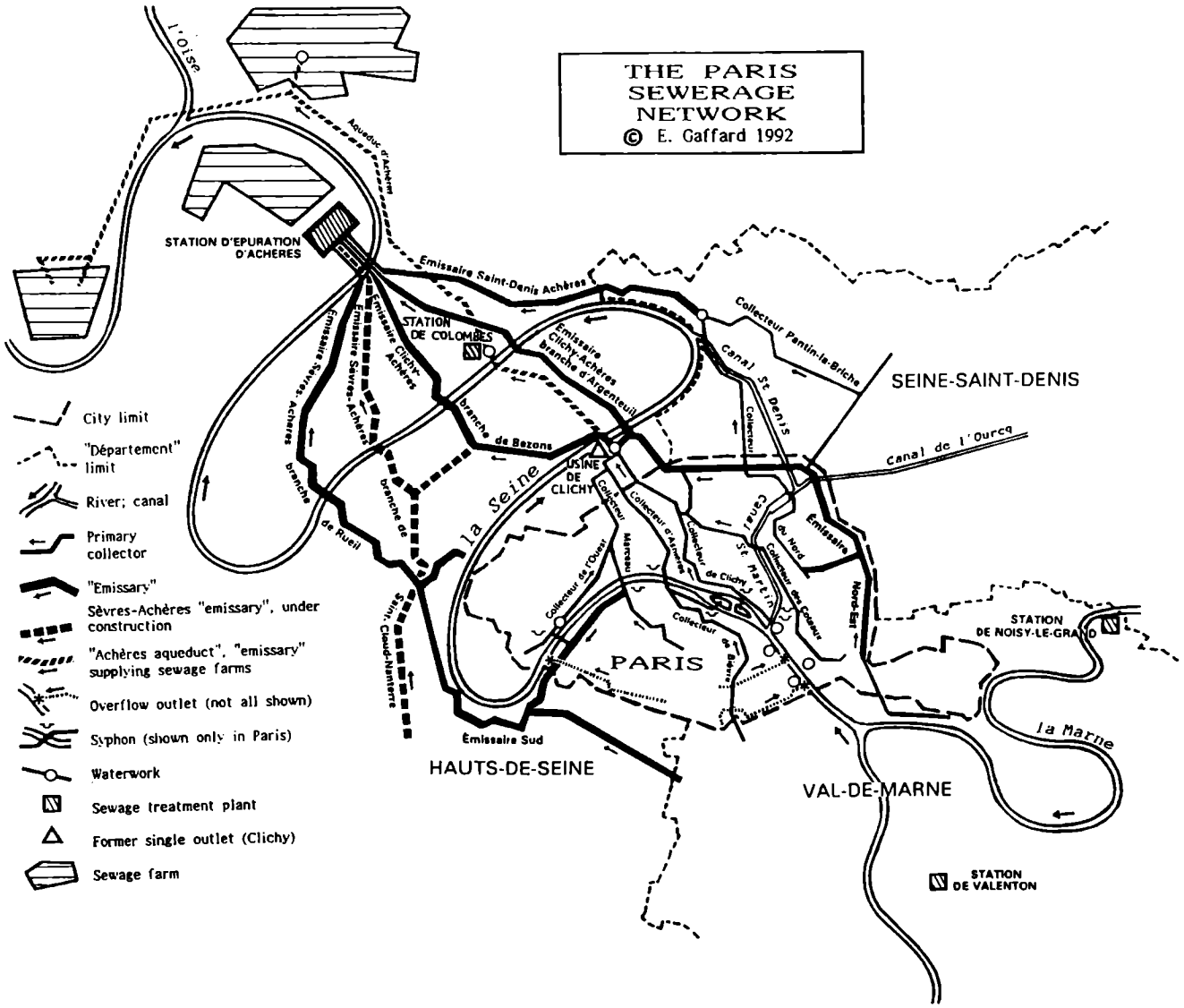

Hazards from Abandoned Mineworkings - A European Perspective

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The Review of Mining Instability in Great Britain has provided a country wide compilation on the location of recorded mineral workings in England, Scotland and Wales. Records of instability associated with mining activity have also been collated to provide some guidance to local authorities on the likely hazards associated with abandoned mineworkings.

The results of the study indicate three main sources of hazard:

i) Instability due to mine entries.
ii) Instability from shallow mines for chalk and limestone.
iii) Instability from shallow mines for metalliferous minerals.

Death, injury and significant damage to surface property have occurred over the years due to the hazards outlines above.

The principle hazard identified is from mine entries, wherever a mineral or material has been intensively exploited. Thousands of these features occur in areas rich in mineral resources. However, bell pit mine entries are widespread across Lowland England, where agricultural material has been dug. They are well known in chalk areas as 'Dene holes' and 'Chalkwells'.

Instability from chalk and limestone mines frequently occurs due to interaction with natural solution features. This type of hazard occurs on both sides of the English Channel.

Instability from mining metalliferous lodes is a particular problem in several areas. Especially where urban development corresponds with a mined area. Parts of south-west England and central Belgium are notably affected.

Risques causés par les exploitations minières abandonnées - une Dimension Européenne
La révision des données au sujet de l'instabilité des mines abandonnées en Grande - Bretagne , a permi de fournir une liste complete sur leur location en Angleterre, Ecosse et Pays de Galles. Les renseignements sur cette instabilité ont été également regroupés sous forme de guide afin d'attirer l'attention des autorités locales sur les dangers posés par les mines abandonnées.

Les résultats de cette étude font apparaitre 3 risques principaux ayant pour cause:

i) Instabilité due aux puits de mines.
ii) Instabilité des mines peu profondes dans la craie et le calcaire.
iii) Instabilité des mines peu profondes pour minerais métallifères.

Les accidents mortels ainsi que les dégàts occasionnés aux constructions durant les années passées sont la conséquence des dangers indiqués ci-dessus.

Les milliers de puits de mines situés dans les régions riches en ressources minières, òu, soit un minerai, soit un matèriau ont été exploité d'une façon intensive, constituent le danger principal. Cependant, les puits de mines en forme de cloche, connus sous le nom de mines à "puits coniques" et mines à "galeries multiples", creusés pour en extraire les materiaux pour l'activité agricole, sont trés répandus dans les régions crayeuses des Basses Terres de L'Angleterre.

L'action rèciproque avec les èlèments naturels est souvent la cause de l'instabilité des mines en zone crayeuse et calcaire. Ce type d'instabilité est courant de part et d'autre de la Manche.

L'instabilité due à l'exploitation passée de minerais métallifères pause un danger pour le dèvelopement urbain situé en zone minière. Le Sud-Ouest de L'Angleterre et le centre de la Belgique en sont particulièrement affectès.

Gefahren Verlassener Gruben. Eine Europäischê Perspektive

Die Nachprüfung mangelnder Stabilität der Gruben in Gross Britanien ist eine umfassende zusamimenstellung eingetragener Gruben in England, Schottland und Wales. Aufgezeichnete Instabilität im Zusammenhang von Grubenarbeiten verschafft eine umfassende Orientierung für die zuständigen Behörden über die voraussichtlichen Gefahren verlassener Gruben.

Das Forschungsresultat weist drei Hauptursachen auf:

i) Instabilität infolge von Grubeneingängen.
ii) Instabilität von oberflächligen kalkstein und Kreidegruben.
iii) Instabilität oberflächliger Gruben von metallhaltigen Mineralien.

Tod, verletzungen und bedeutende Schaden der Oberfläche sind wegen obgenannten Gefahren über viele Jahre vorgekommen.

Die grundsätzlich festgestellte Gefahr ist von Grubeneingängen, wo immer Minerale oder Material intensive ausgenüzt wurde. Mineralreiche Gegenden sind mit tausend solcher kerkmalen geprägt. Wie dem auch sei, Eingänge von Glockengruben sind weitverbreited über das ganze englische Tiefland, wo Material Landwirtschaftlich gegraben wurde. In Kreidegegenden sind sie als Denelöcher und Kreidegruellen bekannt.

Die Instabilität von Kalk und Kreidegruben ist beeinflusst von öfters vorkommenden, natürlichen Auflösungen. Diese Art Gefahr kommt auf beiden Seiten des Aermelkanals vor.

Instabilität durch ausgrabung von metallhaltigem adern ist ein besonderes Problem in verschiedenen Gegenden. Besonders wo Ausbeutung und städtische Entwickling übereinstimmen. Teile von südwest England und zentral Belgien sind besonders betroffen.

The Review of Mining Instability in Great Britain is a major study commissioned by the Department of the Environment (DoE) as part of a wider study of issues on the development of unstable land. Guidance in Planning Policy Guidance Note 14 (DoE, 1990) makes it clear that land stability issued are to be taken into account in the planning approval process, and in the drawing up of regional development plans.

The aim of the Review was to obtain a clear but general picture of the extent and nature of mining instability in Great Britain, and to indicate where mining should be borne in mind when considering planning and development of land.

Ten man-years of research were put into compiling and interpreting information about mines and subsidence events from a wide range of documentary sources, including:

- The British Geological Survey
- Local Authorities (County & District)
- British Coal
- Mineral Valuers
- the Catalogues of Plans of Abandoned Mines
- Various libraries, archives and mining history organisations

The results of the Review have been reported in the series of documents outlined in Figure 1. These consist of 10 Regional Reports, one for each planning region in England, plus one each for Scotland and Wales, accompanied by maps at a scale of 1:250,000 for each County. Each Regional Report describes the type and extent of mining in each county, with a database summary of information for each mine or mining area, plus detailed references to further information sources. There are also 5 Technical Reports dealing with different aspects, each involving a state-of-the-art review. Finally, there are 11 case histories on particular areas, where the problems and the solutions adopted have been examined.

In the Review, a simple way of classifying methods of mining was sought, so that these could be correlated to possible effects at the surface. This is illustrated in Figure 2. In terms of planning and future development, the general subsidence arising concurrently from total extraction is a relatively controlled operation. The biggest occurrence is in coalfield areas, and a compensation scheme exists for damage to property.

The delayed general subsidence arising from widespread partial extraction has also often been previously identified and addressed (to a greater or lesser extent) in areas such as Cheshire for brine pumping, and deep limestone extraction in the Black Country. General subsidence can cause damage to structures and services over a drawn out period of time, from months to years. Perhaps a trickier hazard to deal with is shallow partial extraction leading to delayed collapse causing crownholes. These happen suddenly and cause

deep, steep sided holes, presenting a real risk to life and limb.

Three particular groups pose the greatest hazard within this category, namely:

- mine entries,
- shallow chalk and limestone mines, and
- shallow metalliferous mines

Hazards from Mine Entries

Because of the dramatic effect of collapse, abandoned shafts and adits are well known as hazards in coalfields and other traditional mining areas, but are less well appreciated where mining was not so intense, or where the evidence has been obliterated with time. Fatalities have occurred across the country.

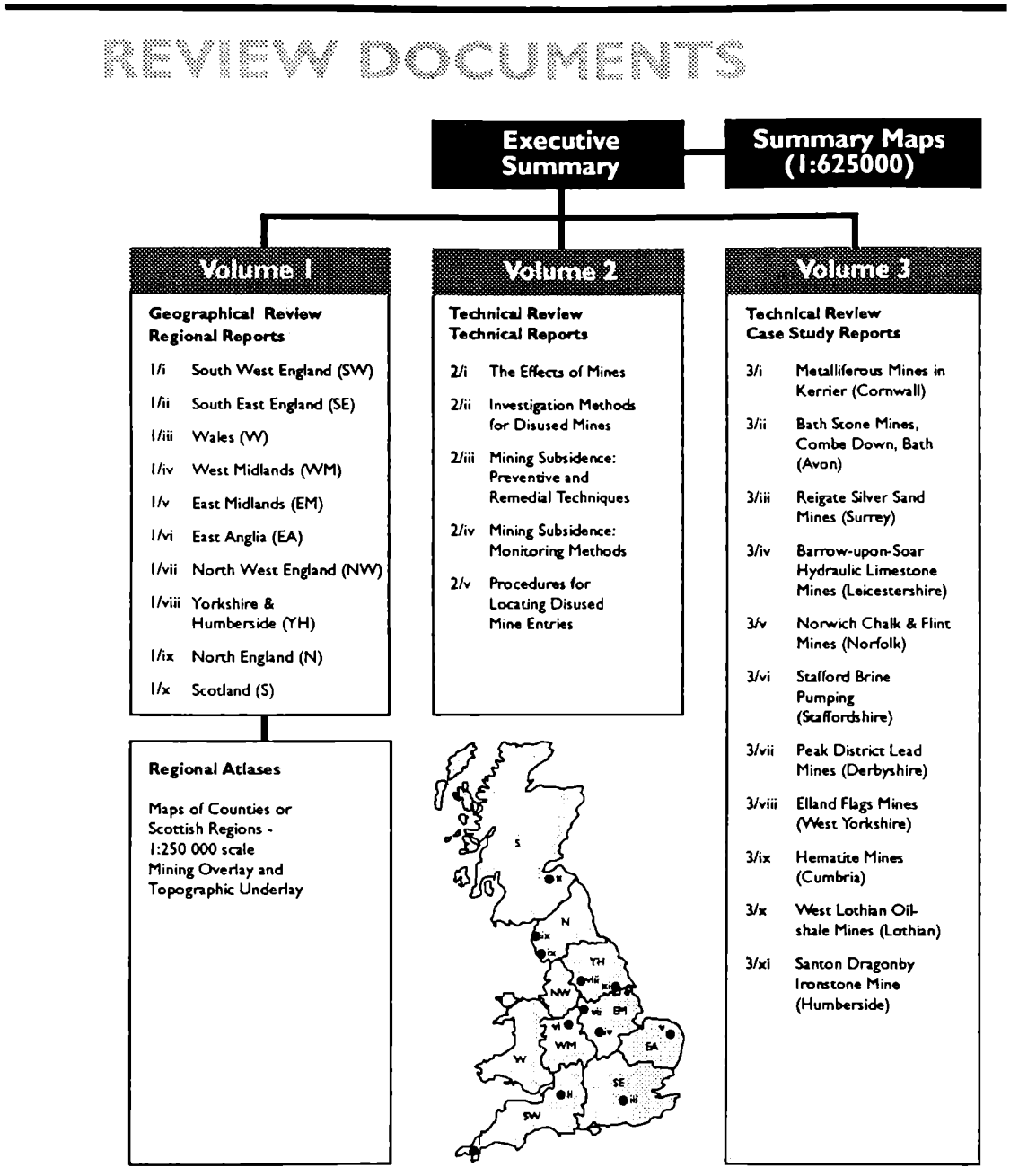
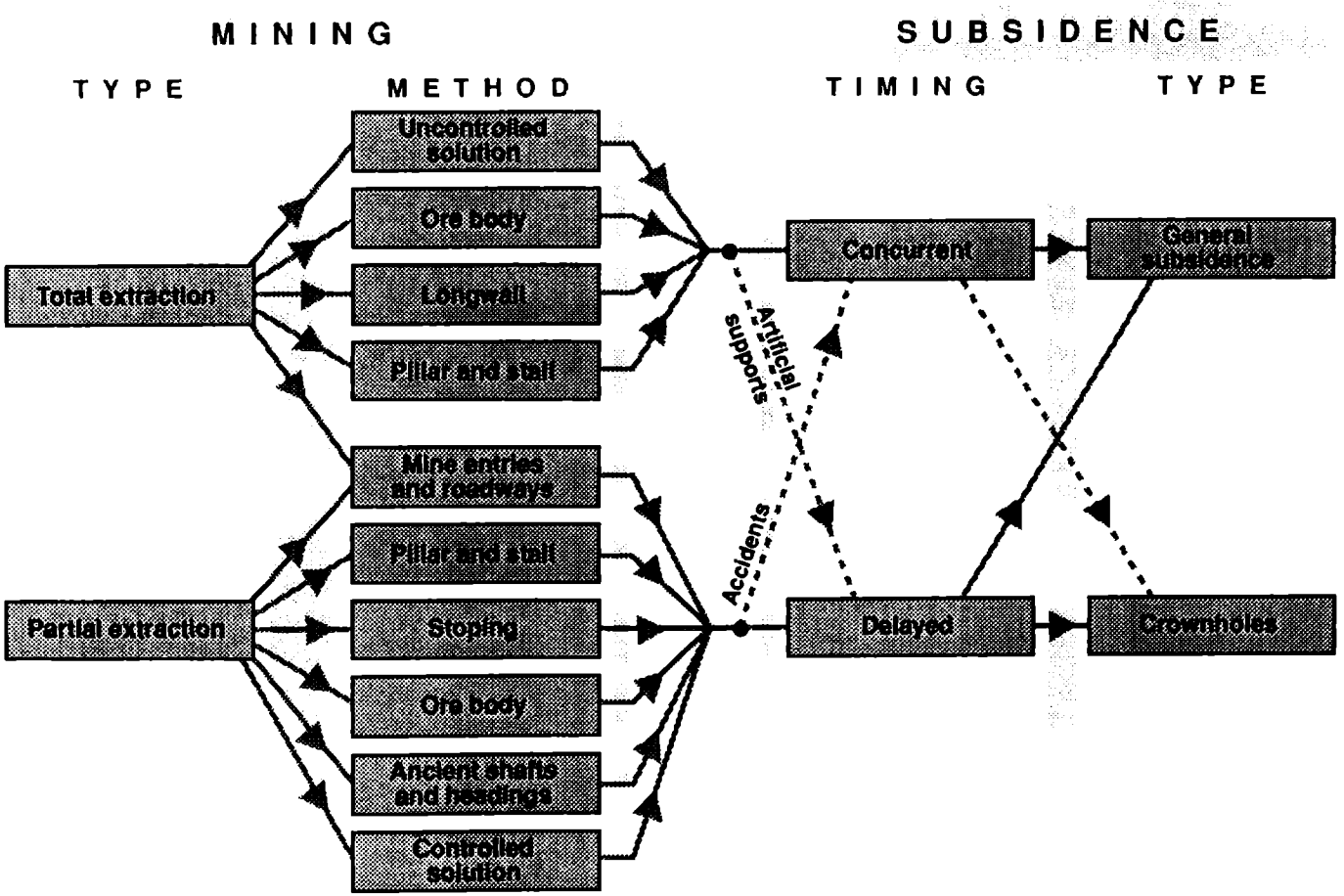


FIGURE 1

SUBSIDENCE EFFECTS OF MINES



ARUP

FIGURE 2

Mined Areas in Great Britain

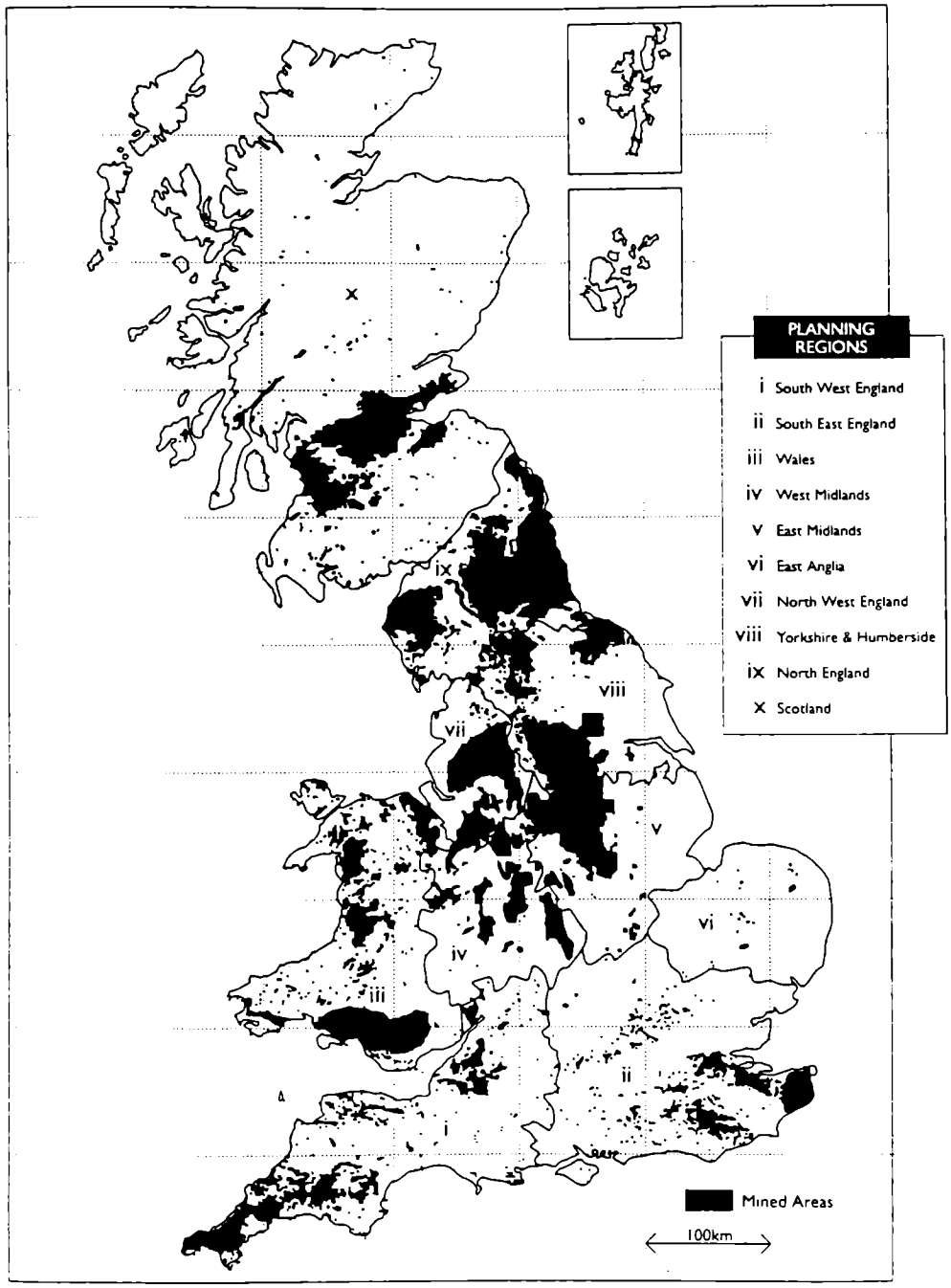


FIGURE 3

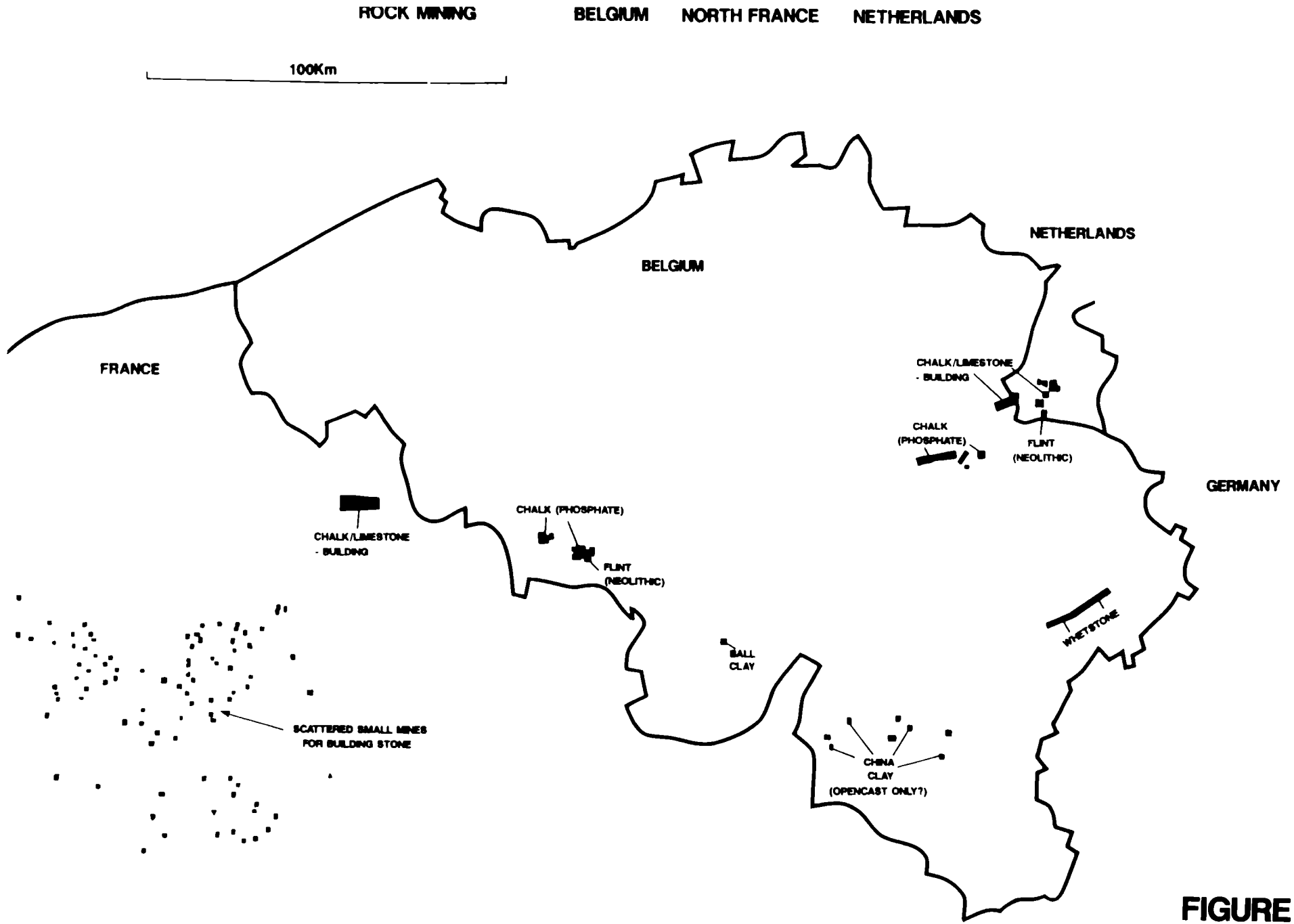
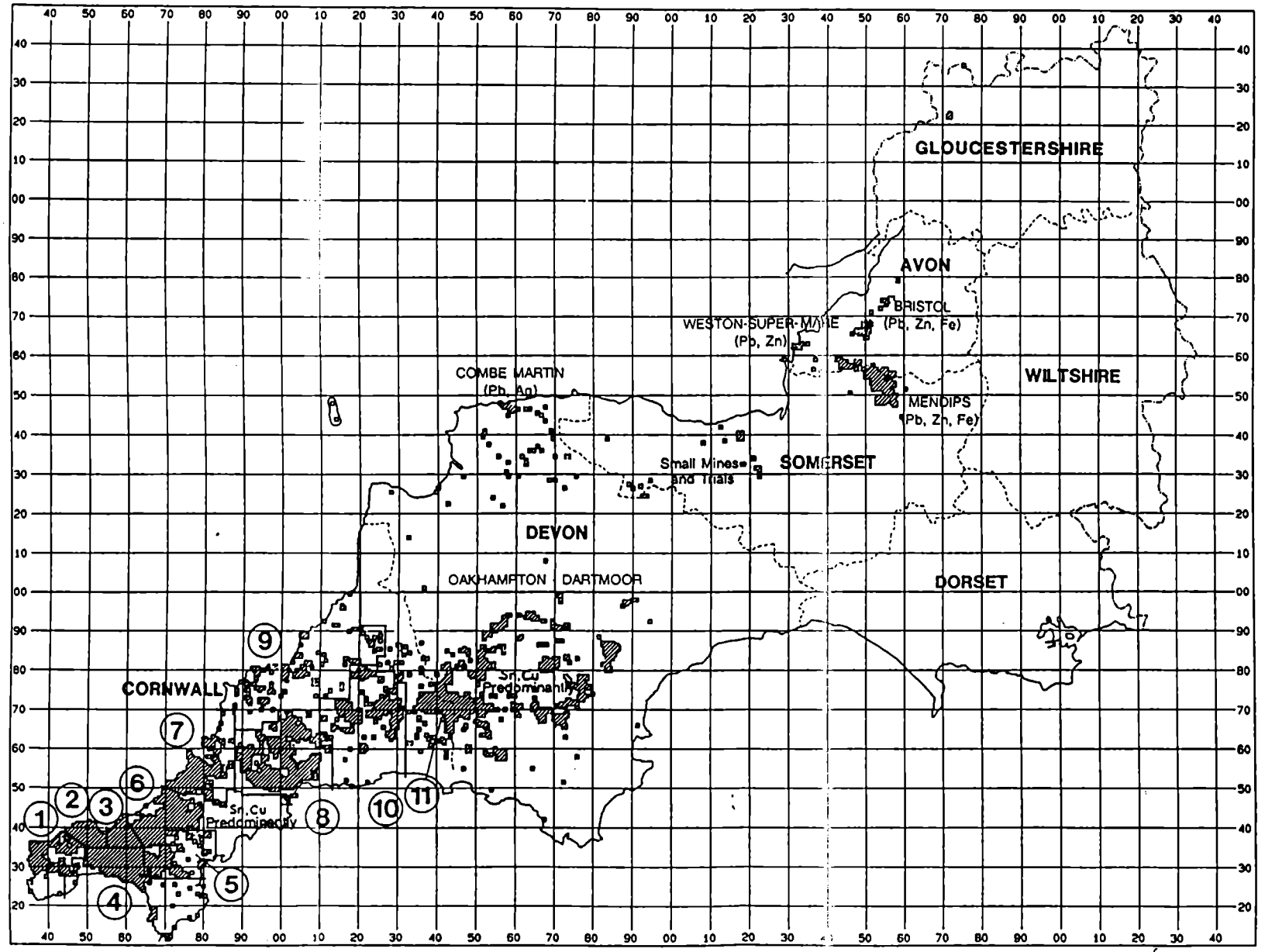

ROCK MINING
BELGIUM
NORTH FRANCE
NETHERLANDS
100Km
NETHERLANDS
BELGIUM
FRANCE
GERMANY
CHALK/LIMESTONE - BUILDING
CHALK (PHOSPHATE)
FLINT (NEOLITHIC)
CHALK/LIMESTONE - BUILDING
CHALK (PHOSPHATE)
FLINT (NEOLITHIC)
BALL CLAY
WHETSTONE
SCATTERED SMALL MINES FOR BUILDING STONE
CHINA CLAY (OPENCAST ONLY?)

FIGURE 4



LEGEND

Cu - Copper

Sn - Tin

Pb - Lead

Zn - Zinc

Fe - Iron

Ag - Silver

MINING DISTRICTS ACCORDING TO DINES (1956)

1. ST JUST
2. ST IVES
3. GWINEAR
4. MOUNTS BAY AND THE LIZARD
5. WENDRON AND FALMOUTH
6. CAMBORNE - REDRUTH AND ST DAY
7. ST AGNES
8. ST AUSTELL
9. WADEBRIDGE
10. LISKEARD
11. CALLINGTON-TAVISTOCK

METALLIFEROUS MINING (NON-FERROUS)

FIGURE 5

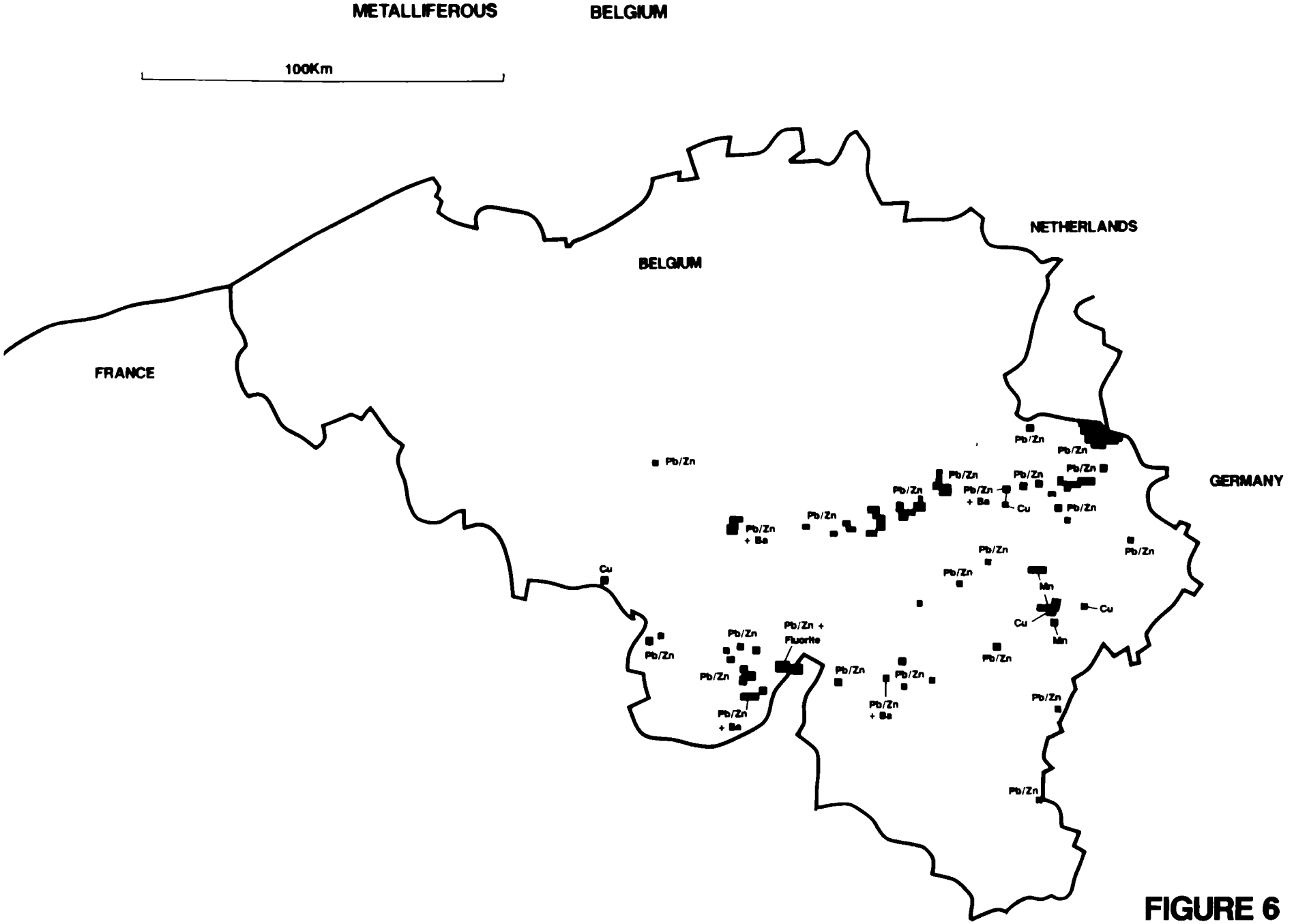

METALLIFEROUS
BELGIUM
100Km
BELGIUM
NETHERLANDS
FRANCE
GERMANY
Pb/Zn
Pb/Zn + Ba
Pb/Zn + Fluorite
Cu
Mn

FIGURE 6

Figure 3 shows that past mining activity has been recorded in every County in England and Wales, including many areas outside those traditionally considered. In particular agricultural mines are widely scattered, where material has been dug for land improvement.

Bell pit mines in the chalk of South East England, locally called Deneholes or chalkwells have been mined from Roman times onward. These have caused problems in the densely populated areas of South East England, with dramatic holes opening up back gardens, just like a mine shaft collapse.

Similar features are known to occur in Belgium and the Netherlands. One example is the quarries of Vechmaal used for agricultural marl, then subsequently mushroom growing and bat sanctuaries. Such agricultural mining was probably also very common across Northern France.

Hazards from Shallow Chalk and Limestone Mines

The distribution of shallow chalk and limestone mines is particularly concentrated in South East England, Northern France, Belgium and the Southern Netherlands.

There have been fatalities in the past in North Kent and in Norwich, where a very well publicised collapse occurred in 1988. A bus fell into a gaping hole that suddenly appeared in the road beneath it, but luckily no one was killed on that occasion.

Stability problems often arise from interaction with natural solution features. Infill in the mine is destabilised and eventually collapse occurs. In 1936 a house in Norwich collapsed into a solution pipe that had formed above a mine. The occupants were killed.

This can be contrasted with limestone mining in the Maastricht area of the Netherlands. Where solution pipes were anticipated, the zone was deliberately avoided. We understand that the miners could tell when approaching such a zone from discoloration of the chalk. However, instability does now sometimes arise in the mines in the Maastricht area from crushing of weak pillars that have gradually degraded over time.

Considering the intensity of recorded mining activity in the chalk in South East England and the selected readily available examples across the Channel shown in Figure 4, the potential intensity of the problem is clear.

Hazards from Shallow Metalliferous Mines

The concentration of metalliferous mines in South West England is shown on Figure 5, with a similar zone in Belgium indicated in Figure 6. Problems particularly occur with urban development over mined areas, with unknown shafts, adits, and shallow worked mineral veins. Large collapses are common.

The most intensively worked area of metalliferous mines in the UK is the Kerrier District of Cornwall, around Cambourne and Redruth. There are over one hundred recorded collapses in that area, with 74 events since 1974. This includes an incident in 1978 when the sudden collapse of a pavement plunged 3 people into a 3m deep hole. They survived, but subsequently surrounding houses were deemed to be unsafe and were demolished.

Conclusions

The purpose of the Review of Mining Instability in Great Britain is to give planners, perhaps with little understanding of geological or mining matters, a handle on the scale and nature of the hazard posed by abandoned mines. The topic has now been brought to the forefront as part of an increasing awareness of wider environmental issues.

Many of us find underground spaces fascinating and accept the risks inherent in visiting them, however, the wider public perception of the risks to surface development, as now categorised, is likely to be that it is unacceptably high. It is unlikely that it will be compared, for instance, with the statistically much greater risk to life posed by the traffic on our roads. The likely response to the problem of abandoned mines is to fill them in, when the finance is available. Arup are engaged in several infilling projects in the West Midlands where improving public safety is the primary objective. However, some problems can be turned into opportunities. We are also working on stabilization schemes to preserve some of the magnificent caverns in Castle Hill in Dudley, for future tourist development.

Carthorse Quarry, Godstone

Survey and Site Investigation, 1990-91

Peter M. Burgess

Carthorse Quarry is one of the Firestone quarries of Surrey, England. Firestone is a refractory stone which was used in furnaces. Carthorse Quarry is about 17 miles (27 km) from London. It was last worked for stone in the 19th century. Mushrooms were grown in the quarry from about 1900 until 1930. During WWII the quarry was used as a secure store for wines and spirits, also for museum collections, to protect the contents from German bombs. The quarry has not been used since 1945.

To adapt the quarry for mushroom-growing, the quarry waste which lay on the floor was removed and put into passages not wanted for this activity. A shaft was dug to ventilate the quarry and wooden doors were installed to control it. Pipes were fitted to carry water into the quarry. Carthorse Quarry is the only quarry at Godstone used for mushroom growing which had electric lighting installed.

When the quarry was used for storage, many heavy steel doors were fitted. These doors divide the quarry into separate areas. Each area had two entrances for safety. Most of the stores were used by wine merchants. One area was used by the British Museum of Natural History, London, for storing specimens.

Champignon-Anbau und Kriegszeit Speicher in Carthorse Quarry, Godstone.
Carthorse Quarry ist ein "Firestone" (Art Sandstein) Steinbruch in Surrey, England."Firestone" ist ein hitzebeständiges Gestein, das in Schmelzofen Verwendung fand.

Carthorse Quarry liegt ungefähr 17 Meilen (27 km) von London entfernt. Im 19. Jahrhundert war der Steinbruch zuletzt bearbeitet worden. Von ungefähr 1900 bis 1930 wurden Champignons in dem Steinbruch angebaut. Während des zweiten Weltkrieges diente der Steinbruch als sicheres Lager fur Weine und Spiritüosen, wie auch für Museums Sammlungen, um sie vor deutschen Bombenangriffen sicherzustellen. Der Steinbruch ist seit 1945 nicht benützt worden.

Um den Steinbruch auf Champignon-Zucht umzustellen, wurden die Schlacken vom Boden beseitigt und in die Gange gefüllt, die nicht zu diesem Zweck benötigt wurden.

Um für Ventilation im Bergwerk zu sorgen, wurde ein Schacht gegraben, und Holztüren zur Kontrolle angebracht. Röhre wurden angelegt um Wasser in den Steinbruch zu bringen. Carthorse Quarry ist der einzige Steinbruch in Godstone, der zur Champgnonzucht benutzt wurde, und in welchem elektrisches Licht installiert wurde.

Für die Benutzung des Steinbruchs zur Lagerung sind mehrere schwere Stahltüren angebracht worden. Diese Türen teilen den Steinbruch in einzelne Gebiete auf. Jedes Gebiet hat aus Sicherheitsgründen zwei Eingänge. Die meisten der Lagerräume wurden von Weinhändlern benutzt. Ein Teil wurde vom Britischen Museum für Naturgeschichte zum Lagern von Exemplaren benutzt.

La Culture des Champignons et le Depot de vins dans "Carthorse Quarry
"Carthorse Quarry" (la Carrière du Cheval de Trait) est l'une des carrières de "firestone", en Surrey, Angleterre."Firestone" est une pierre réfractaire employée en des fourneaux."Carthorse Quarry" est située environ 17 milles (27 km) de Londres. On l'a exploité la dernière fois pendant le 19ieme siècle. On cultivait des champignons dans la carrière depuis 1900 jusqu'a 1930. Pendant la bombardement allemande de 2ième la guerre mondiale, on a aménagé la carrière en dépôt de vin et pour des objets de musée. La carrière est hors d'usage depuis 1945.

Quand on a aménagé la carrière pour la culture des champignons on a déplacé les détritus de la carrière aux zones dont on n'avait pas besoin. On a ventilé la carrière par un puit d'aération et des portes de bois. Des tuyaux d'acier ont conduit l'eau dans la carrière ."Carthorse Quarry" était la seule carrière de Godstone, utilisée pour la culture des champignons, où on a installé des lampes électriques.

Quand la carrière est devenu un dépôt de vins, on a installé beaucoup de portes lourdes en acier. Ces portes divisent la carrière aux zones séparées. Toutes les zones ont deux entrées pour plus de sûreté. Des négociants en vins ont utilise la plupart des zones. Le Musee Britannique de L'Histoire Naturelle, de Londres, a enferme a clef des specimens zoologiques dans une zone particuliere.

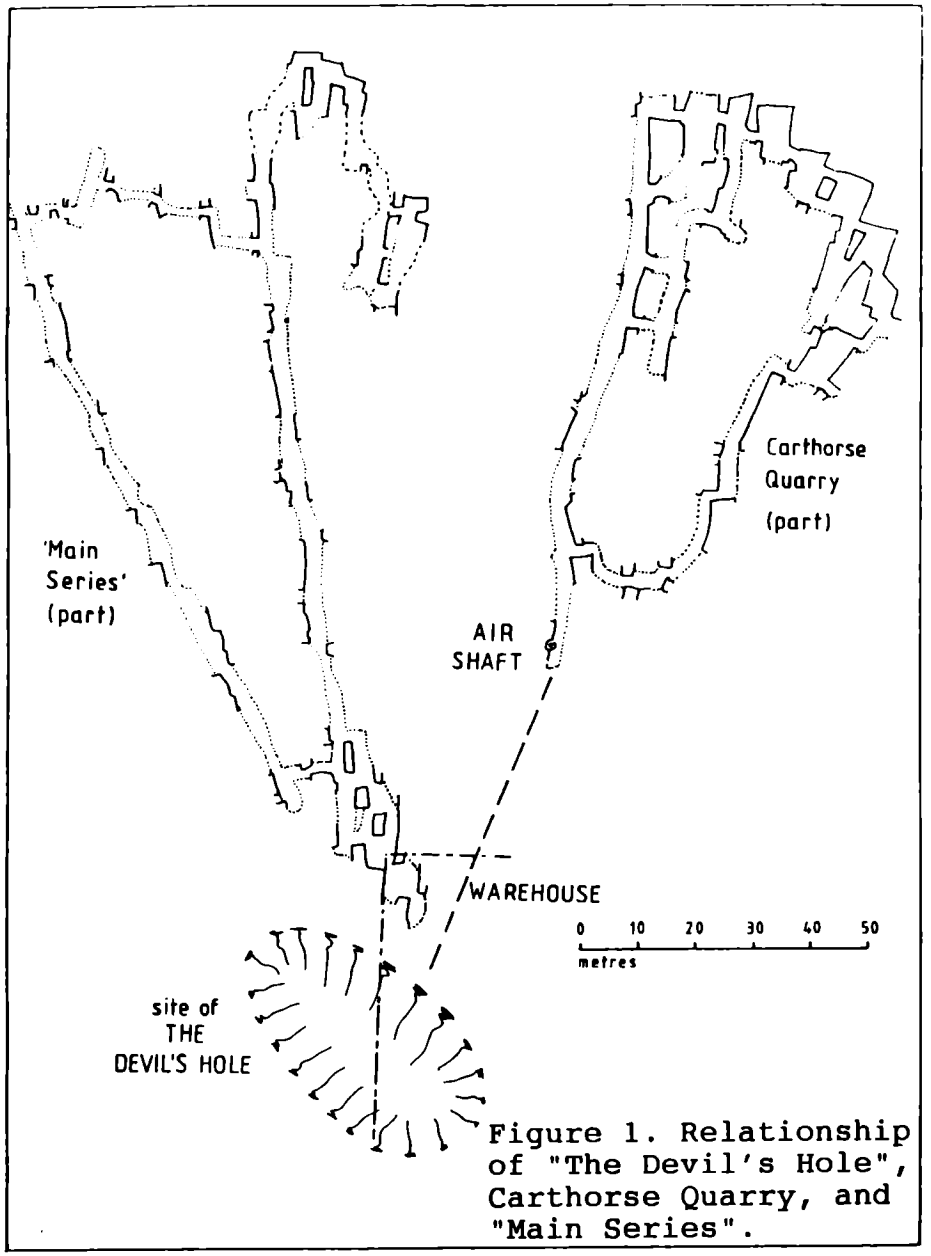


Figure 1. Relationship of "The Devil's Hole", Carthorse Quarry, and "Main Series".

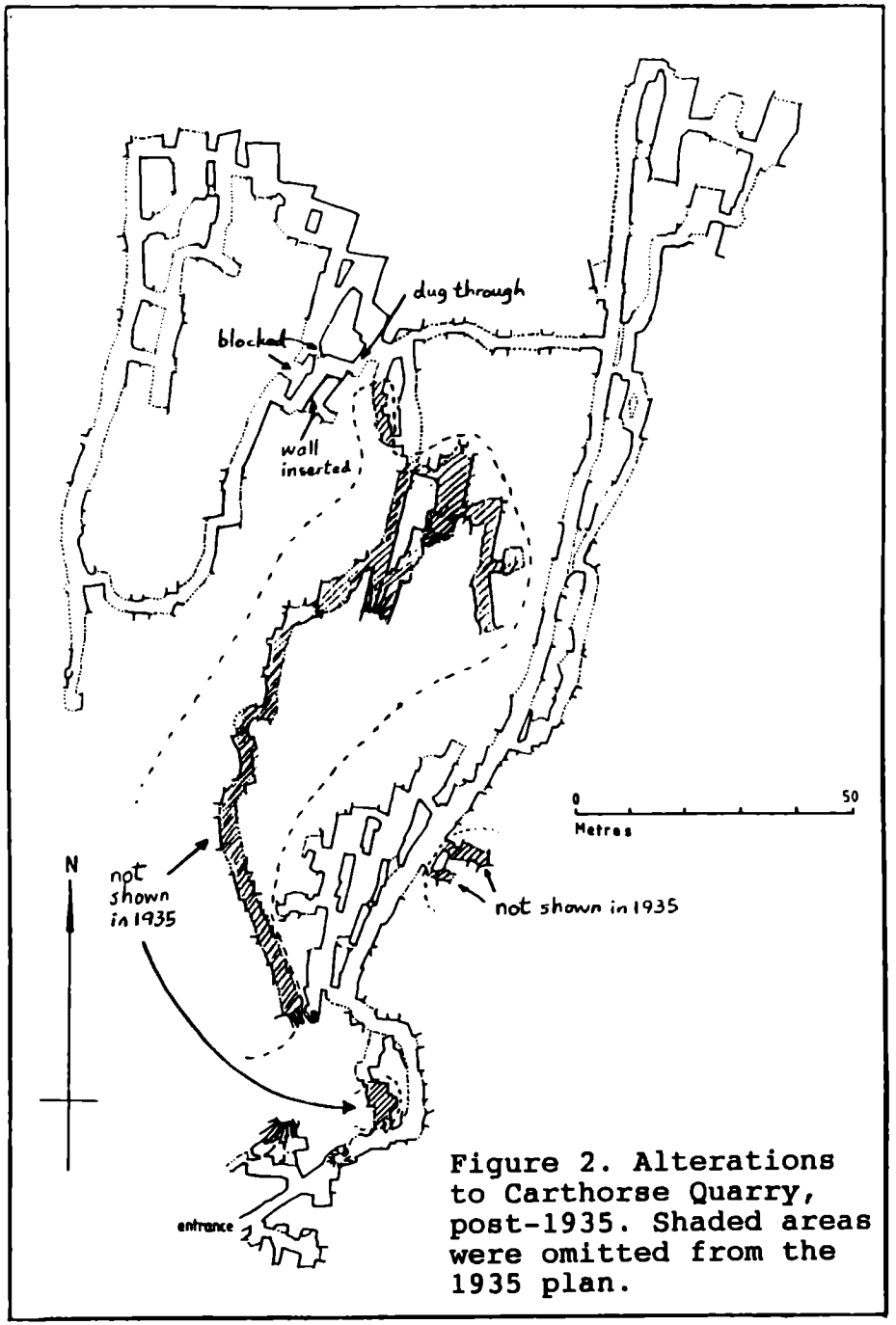


Figure 2. Alterations to Carthorse Quarry, post-1935. Shaded areas were omitted from the 1935 plan.

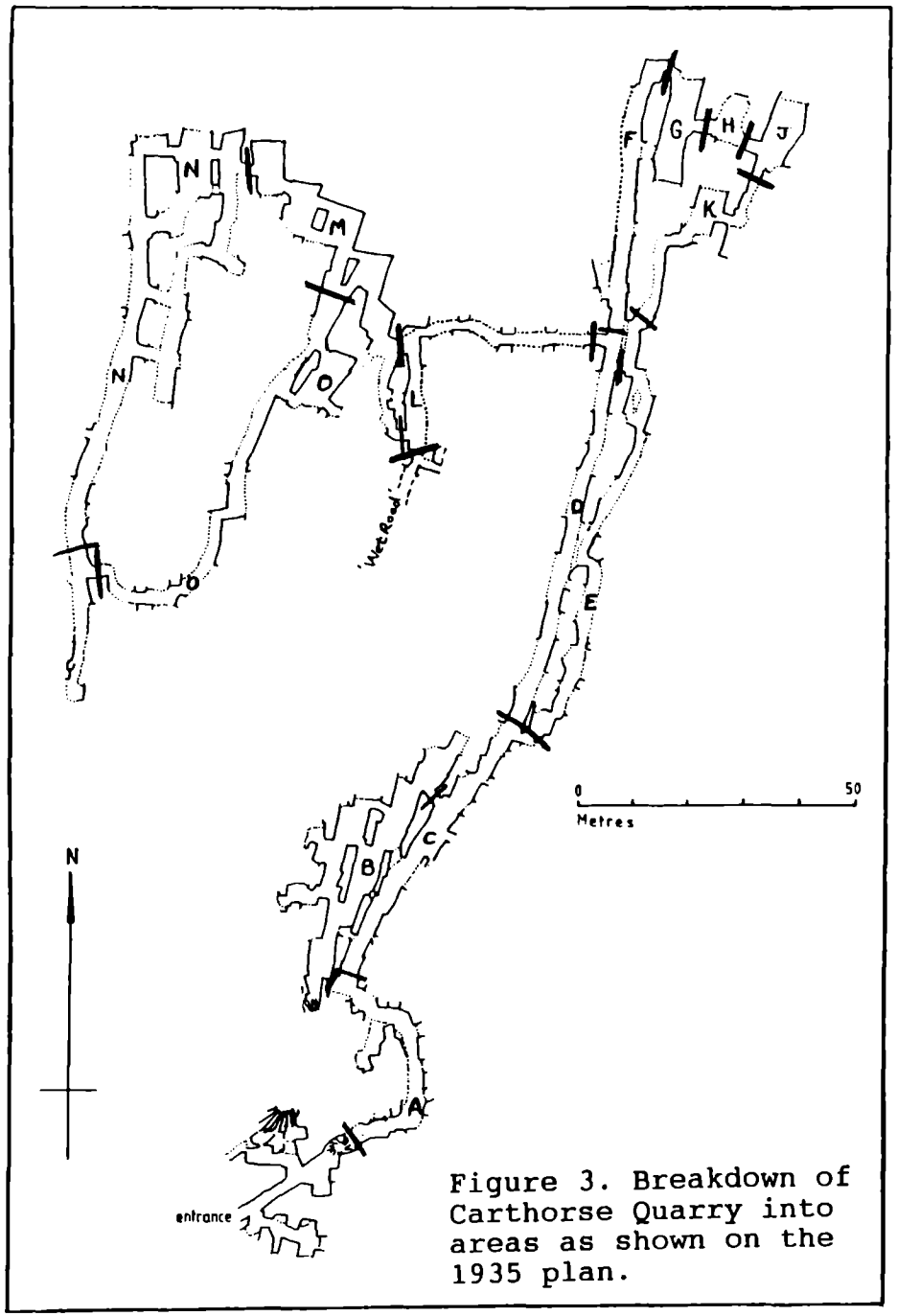


Figure 3. Breakdown of Carthorse Quarry into areas as shown on the 1935 plan.

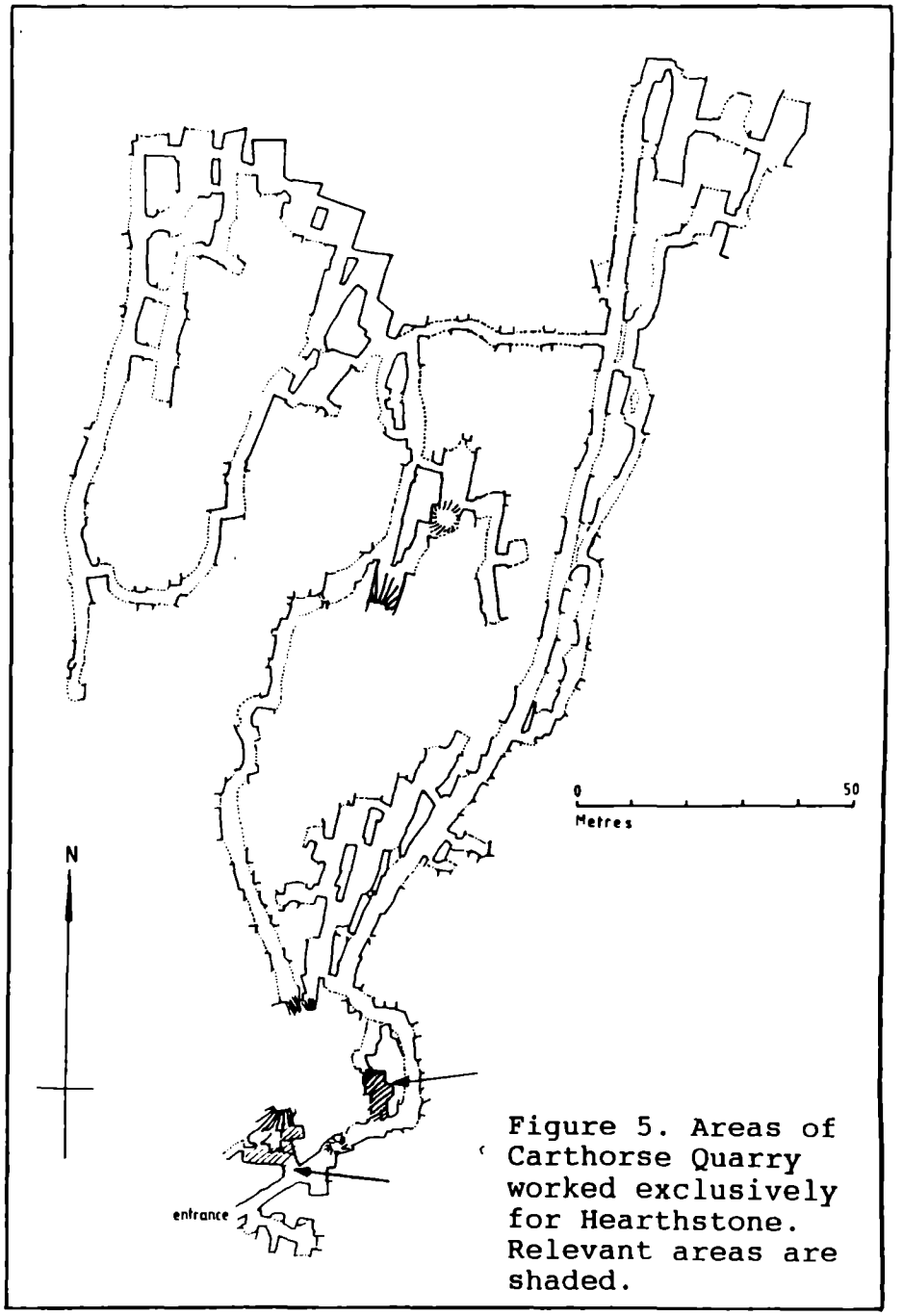
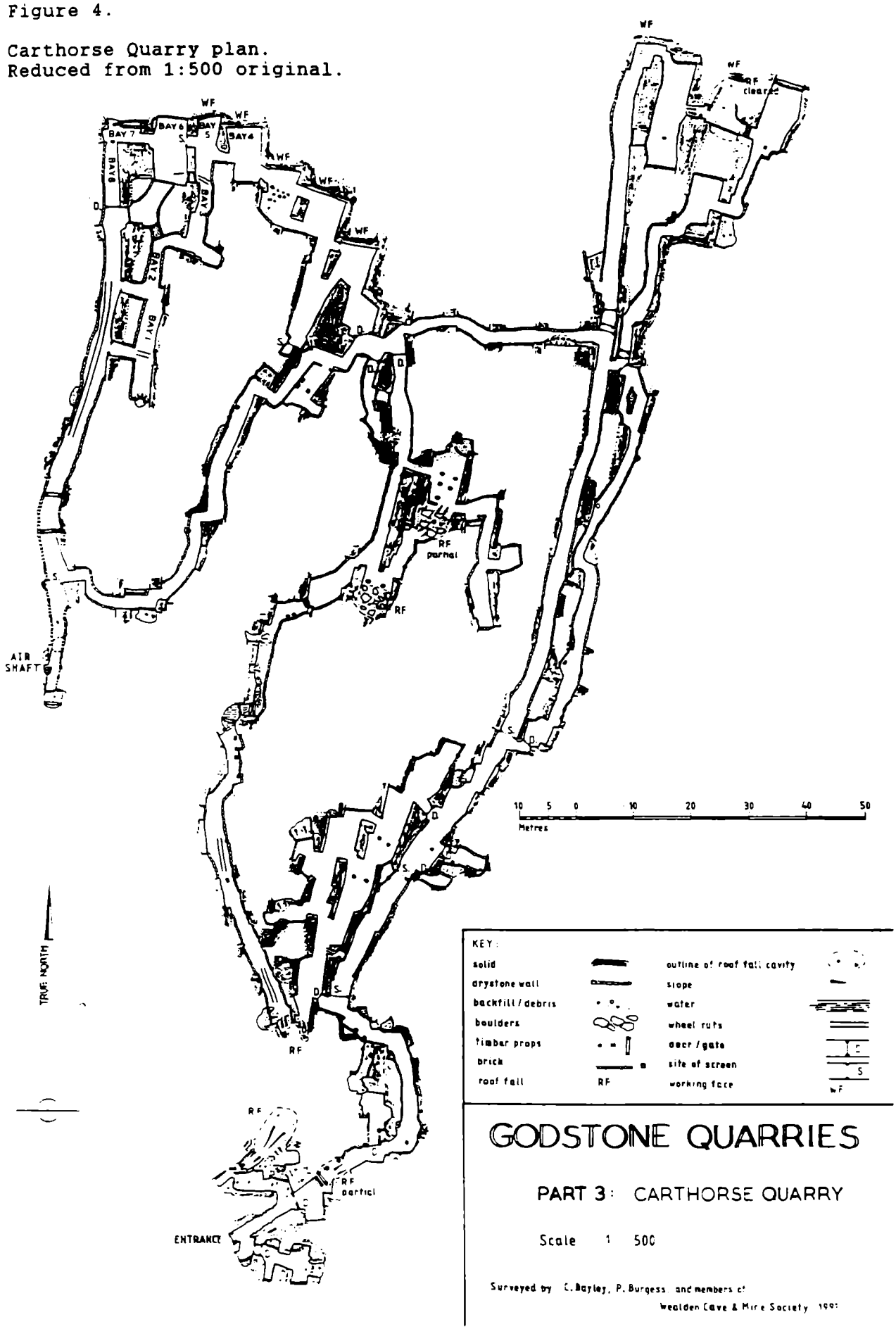


Figure 5. Areas of Carthorse Quarry worked exclusively for Hearthstone. Relevant areas are shaded.

Figure 4.

Carthorse Quarry plan.
Reduced from 1:500 original.



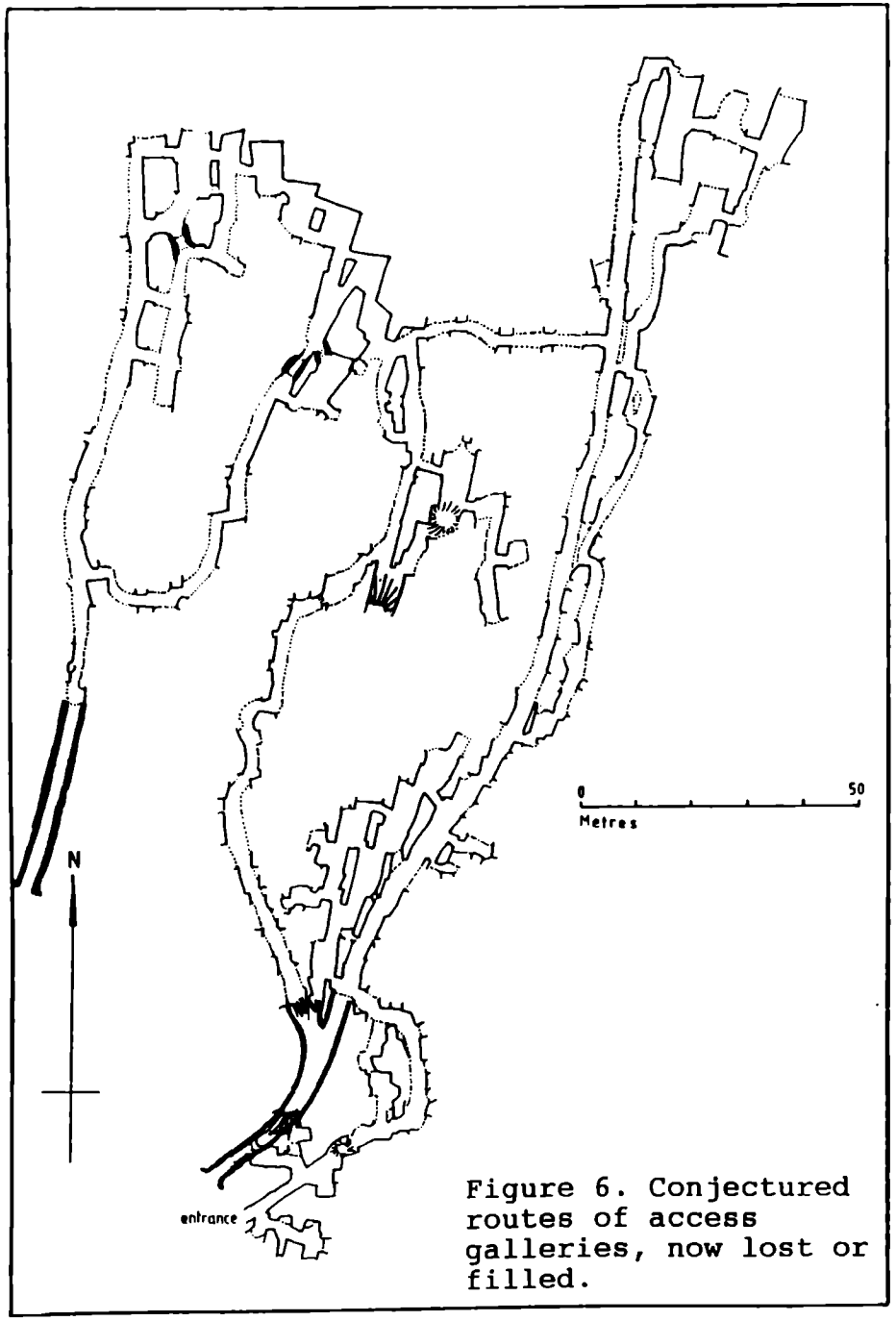


Figure 6. Conjectured routes of access galleries, now lost or filled.

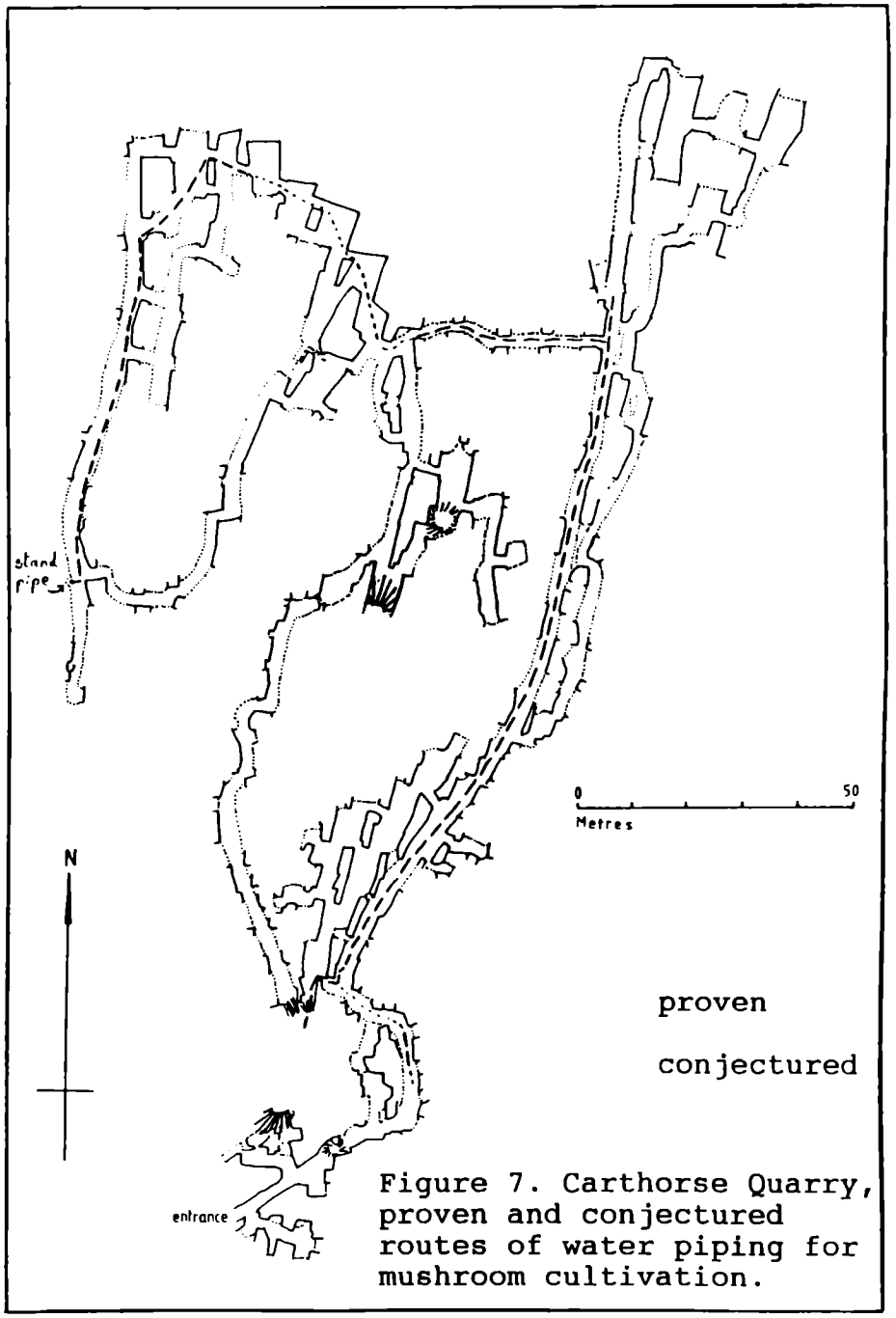


Figure 7. Carthorse Quarry, proven and conjectured routes of water piping for mushroom cultivation.

Introduction

Carthorse Quarry is the name given to workings in the Upper Greensand, north of Godstone village in East Surrey. The quarry is located underground, and is one of a number of similar workings at numerous places from Godstone, westwards as far as Brockham.

The quarry entrance is on land owned by Fry Properties Ltd., and is kept secure from unauthorised access by a locked steel door. In the summer of 1990, Mr I. W. Fry granted access to the quarry for the purpose of undertaking the research described in this report.

The author wishes to acknowledge the valuable assistance of the following people: Mr I. W. Fry for granting permission to enter Carthorse Quarry, Mr. J. Gardner for his involvement in gaining access, Mr C. I. Bayley for leading the survey work, Mr N. Catford for his photographic work, Mr M. A. Clark for regular assistance with the surveying, Mr S. Mickleburgh for his bat survey, Mr P. W. Sowan for the results of many years of documentary work made available to me and all members and friends of WCMS who have assisted from time to time.

Background

The rocks of East Surrey were laid down during the Cretaceous period (135 to 70 million years ago) and are on the northern edge of the Weald. The North Downs are formed of Chalk, the youngest of the major rock types in the area. Immediately below the Chalk, the Upper Greensand is to be found. It occurs as a comparatively thin stratum, and takes a number of similar forms, varying from soft olive-coloured sand to a hard compact sandstone. A bed of this latter form has been worked for a building material since the time of the Normans; a reference to two stone pits near Chaldon may be found in the Domesday Survey of 1086.

During the years that followed, the building stone beds in the Upper Greensand were exploited at a number of places from Brockham to Godstone. In all workings that have been inspected in recent times, a form of extraction known as pillar and stall has been employed. This involves the removal of about three quarters of the rock, leaving rectangular pillars to support the roof. The gallery plan that results is a form in which approximately parallel passages are joined at intervals by "eyes" cut through the separating wall with varying degrees of regularity.

The quarrying operations generated a considerable amount of waste material which was put into disused galleries, and along the sides of working galleries. As a consequence, the quarries do not have a particularly open layout, but are a set of branching access routes leading through largely back-filled sections to the working faces. The waste rock is usually to be found neatly walled up behind drystone walls, themselves built with the waste rock.

The rocks of the district dip gently to the north at an angle between five and ten degrees. Consequently, the galleries in the quarries dip at the same angle, occasionally intercepting the ground water level, preventing further progress northwards.

During the nineteenth century, a market developed for hearthstone for which new mines were opened in Surrey. Hearthstone was used for whitening domestic hearths and doorsteps. The new mines tended to be developed at a higher level than the older stone quarries. However, the latter were also worked for hearthstone, sometimes continuing to supply building stone as well.

Carthorse Quarry is an old stone quarry, later worked for both building stone and for hearthstone, and finally, just for hearthstone. The evidence for this conclusion is given below, and results from a close inspection of the quarry layout, and of the quarry walls and working faces.

After stone extraction ceased, the workings were adapted for use as a mushroom farm, as were most of the underground quarry workings under and close to Godstone Hill. These operations probably started in about 1900, and continued intermittently until the 1930's. There was a brief revival after 1945, but this did not affect Carthorse Quarry. During the 1939-45 hostilities, Carthorse Quarry was further adapted for use as a store for wines and spirits, and for museum collections, safe from enemy bombing. Since abandonment, many of the quarry and mine entrances have been sealed for safety reasons. Some sites are still accessible due to the installation of secure gates to deter casual visitors.

Site Description

The workings are entered through a steel door in a low cliff close to the offices of Fry Properties. This door is kept securely locked. The quarry is typical of the Godstone quarries in many ways. The stone was extracted using the pillar and stall

system, already described. The waste stone has been stacked into disused galleries and neatly walled up with drystone walling. There seems to be a very high proportion of filled galleries to open ones, perhaps indicating a poorer quality of stone here compared to quarries to the west, which tend to be more open.

The workings, as a result of the post-quarrying uses summarised in the previous section, are untypical of a stone quarry, which are usually untidy places with piles of waste rock and half-filled galleries. Carthorse Quarry in contrast is a very tidy site. To facilitate the adaption of the workings as a mushroom farm, the gallery floors have been cleared, and any part-filled galleries have been properly sealed up with drystone walling. In a number of places, passages have been blocked to allow the more effective partitioning of the site for mushroom growing. Control of ventilation is important for mushroom cultivation, so restricting the number of openings between sections is a major consideration.

A ventilation shaft is located at the extreme western end of the workings. This was built by the mushroom growers. Of the several such shafts built into the Godstone quarries, this is the only one of which the brick chimney on the surface has survived, largely intact. The shaft is blocked by concrete at its base.

The gallery walls and roof have been thoroughly covered with white paint, or lime-wash, except for a few small sections of the workings. Other Godstone workings have been similarly treated, but only in Carthorse Quarry and Marden Quarry does the treatment include the roof. It is known that it was one of the mushroom cultivation procedures to so treat the gallery walls, a practice still undertaken in the active underground mushroom farm at Bradford upon Avon, in Wiltshire. Painting the walls improved the hygiene of the site, and rendered more effective the lighting installed, by providing a reflective surface.

Doorways and screens installed to partition the mushroom farm are still in evidence, but the most obvious doorways are those which were installed during the Second World War. These are all of steel, either plate or grill. They are either fitted directly to the quarry wall or to steel door-frames set into brick surrounds.

Upon the walls of the quarry, there is much evidence of electric lighting having been installed, with the remains of insulated cable ties, switch boxes, and the electric lamps themselves. All of the wooden features of the lighting installation are extremely rotten. There were two phases of electric lighting, the first being a D. C. supply installed by mushroom growers, and the later war-time installation being A. C., presumably connected to the mains supply which arrived in Godstone in 1936.

Throughout the quarry, timber props have been installed to support the roof. These are both old railway sleepers and sections of tree-trunks, cut to length. In most cases, single uprights are surmounted by a short load-spreading timber; in a few places two uprights support a horizontal timber spanning the quarry gallery.

Historical and Documentary Study

Quarry Leases

There are very few historical references to Godstone quarry workings before the 20th century in which particular sites may be identified. Quarry leases have survived from the 17th century onwards, but many are rather imprecise with regard to location. All the surviving leases are for property in the ownership of the Clayton family, occupiers of the Marden estate. It appears that two distinct sites were worked from c. 1700, namely workings below Fosterdown, and others below Winders Hill, or 'Wymers Hill' as it was called.

Bearing in mind that the locations given are probably those of the quarry yards and associated entrances, we can say that it is likely that the two quarries referred to were located under the present alignment of the A22 over Godstone Hill (the Fosterdown site), and in the deep coombe now occupied by the warehouse complex at Quarry Mills (the Wymers Hill site).

This being so, then the earliest reference to quarry workings in the Carthorse Quarry area dates from 1705, in which year Henry Dye of Godstone leased farm land at Godstone Hill, together with two stone quarries (Ref. 1). The land that Henry Dye occupied is described in the lease as being 'at the bottom of Wymers Hill', and the quarry was 'neere adjoining', quite possibly the early Carthorse workings. Associated with this quarry were 'two houses or hovells to keep, lay up, and work stones in'. The other quarry was part of property to the west of the old London road, below 'ffosters downe'.

In 1730, Robert Ockley of Godstone took out a lease of the same properties (Ref. 2), which now included the 'New Quarry House', presumably the Quarry Farm which stands today, which by appearance may date from about this time. The new lease describes the Old Quarry House as being 'on the west side of Godstone road',

possibly one of the two extant buildings on the west side of what is now Quarry Road. This document refers to three buildings associated with the 'Wymers Hill' quarry for storing and working the stone.

There are no further Clayton leases which specifically refer to workings in the approximate location of Carthorse Quarry. This may be because, by the middle of the eighteenth century, the galleries had become physically linked with the more extensive workings further west, for which lease documents dating up to 1890 have survived. Evidence for such a link exists both in the juxtaposition and layout of the galleries in the respective workings, and in notes made by G. F. Harris during a visit to the workings at Godstone in 1893 (Ref. 3).

Published Reports

Before the comparatively recent investigations by caving clubs in the underground sites of the area, there had been no known published reports of visits made to any workings identifiable as Carthorse Quarry. However, on his visit to the Godstone Hill workings to the west in 1893, G. F. Harris made careful notes of his observations. In talking to either the manager or the quarrymen, he was told that the quarry he visited was opened in 1737, and had since been connected with three adjacent quarries, namely Three Bushes Quarry opened in 1625, Devil's Hole Quarry opened between 1625 and 1737, and Arch Quarry opened since 1737. Although the dates should be regarded with caution, the identification of the various constituent parts of the Godstone quarry he visited relates well to place names and the workings as they are known today.

A feature known as the Devil's Hole was recorded by the Ordnance Survey on its first edition 25" plan of 1869 (see below under "maps"). This was almost certainly an entrance pit both to what is now the most easterly section of the Godstone Hill workings, and to the western half of Carthorse Quarry. The site of the pit is now occupied by the north western part of the large warehouse. Thus we may infer that Devil's Hole Quarry consisted of both these sections of quarry, which were probably once connected. The approximate position of the Devil's Hole and the adjacent quarries are shown in Fig. 1.

One more recent account of Carthorse Quarry is given by Mr James Gardner writing in 1963 (Ref. 4). He informs us, inter alia, that Carthorse Quarry derives its name from a horse falling through the road into the workings, and that Godstone workings were used during the Second World War to house museum collections, and both duty-paid and bonded stocks of wines and liquors. As Marden Mine to the east is known to have been the Bonded Store, by implication, Carthorse Quarry housed everything else, as no other Godstone quarry is believed to have been adapted for storage purposes. This is borne out by the evidence found within the workings, described below.

Surveys

Before the current work was undertaken, only one survey was known to exist of the workings (Ref. 5). This was made in 1935 on behalf of the Surrey Timber Company, then occupying the sawmills site, where the warehouse now stands. This plan survey shows the galleries in outline only, and it is clear that a number of changes were made between the time of the survey and the present. Primarily, these consist of the opening of a few galleries, and the walling-up of others. These minor changes are likely to have been made when the quarry was adapted for wartime storage. As part of this exercise, a number of steel doors and gates were installed, which are not shown on the 1935 plan. Some partitions or doors are shown, and these are likely to have been fitted as part of a mushroom farm. The remains of some of these older wooden features are still in situ. The changes made since the 1935 plan are indicated on Fig. 2.

The quarry is shown broken down into a number of lettered sections. Each section is shown with its floor area in square feet. It is unlikely that the site was being considered for wartime uses as early as 1935, and it may be that the timber company were seeking to lease the quarry out to a mushroom cultivator, floor areas being a primary consideration in such a matter. The breakdown of the quarry into areas on the 1935 plan is shown on Fig. 3.

At some later time, probably in the 1960s, the "Wet Road" was surveyed and added to a copy of this plan. This in turn was used in the publication "Secret Tunnels in Surrey - Vol. 2", published in 1965 by the Chelsea Speleological Society. Apart from the minor fall a few yards inside the entrance and one or two others in small areas not surveyed in 1935, all the roof-falls in the quarry are represented on the 1935 plan, indicating that the accessible parts of the quarry are reasonably stable.

Maps

Published maps of the area reveal little of the history of Carthorse Quarry. The nature of the Surrey firestone quarries is such that they had little impact on the surface topography. The most

obvious surface features were the entrances, and buildings in and around the quarry yard. In many cases, the entrances were little more than openings into the hillside, but were sometimes located around the base of pits sunk to reach the bed of stone to be worked.

The oldest map inspected dates from 1761, and is one of a series of maps made to represent the estates of Sir Kenrick Clayton. Within a plot of land called 'Quarry Bank', a building, and an unidentifiable feature represented by a small circle are shown (Ref. 6). It is possible that the second feature is the mouth of a quarry, though it is not labelled as such. The location of this feature is possible the same as the Devil's Hole. Quarry Bank is now known as Dialbank Wood.

The deposited plan of a projected extension to the Caterham Railway to Marden Quarry (Ref. 7), in 1855, shows nothing more in the area of Carthorse Quarry than the sawmill then occupying the site. The plan deposited for a projected railway from Caterham to Godstone village (Ref. 8), however, drawn in 1879, shows the Devil's Hole feature as an old stone quarry in the occupation of Archibald Frederick Paull.

The third edition Ordnance Survey 25 inch plan of 1910 is the first to show the ventilation shaft chimney, which was not represented on the previous edition of 1895. Unfortunately, the 1895 second edition plans of the area are known for errors and omission of significant features, and the lack of representation of the chimney cannot be taken as proof of its absence.

Site Investigations

Surveying Operations

The survey was produced using tape and compass methods. This surveying technique has been successfully used in other firestone quarries in the area. For the purpose of site interpretation, this method is perfectly satisfactory, and positional accuracy can be very good, provided measurements are made with care. All compass bearings were taken in both directions along the tape to check for magnetic anomalies. The only significant magnetic anomalies were within a metre or so of the heavy steel doors, and in the immediate vicinity of the office building outside the quarry.

Tapes were read to the nearest 0.1 metre, and unaffected compass bearings are correct to ± 0.5 degrees. All surveyed loops closed within acceptable tolerances. No attempt has been made to measure the vertical range of the workings. If required, the approximate depth of any part of the quarry from surface can be determined by means of Magnetic Induction Location Device equipment. The angle of dip of the galleries is considered too low to significantly affect the true lengths of the survey legs. All measured lengths have been assumed to be horizontal.

The details represented on the survey are as follows:

Gallery wall type	- solid rock
	- drystone wall
	- brick
	- loose quarry waste
Roof supports	- timber props
	- brick pillars
Floor features	- wheel ruts
	- scattered quarry waste
	- ponded water
Other features	- Ventilation shaft
	- doorways
	- location of screens
	- working faces
	- calcite flowstone
	- roof falls

A copy of the survey is appended, and is designated Fig. 4.

Photographic Survey

A number of photographs of Carthorse Quarry have been taken by Nick Catford. These consist of numerous general views in different parts of the quarry, and a number of illustrations of specific features, to record items of particular significance to the quarry. *(A selection of these photographs follows this paper – Editor)*

Archaeological Survey

No excavations have been conducted within the workings. Because the quarry galleries have been cleared of all debris down to solid rock, and the cleared material has been used to completely fill other galleries, excavations are either irrelevant or impractical. To determine the occupational history of Carthorse Quarry, the evidence of wall-markings, mushroom farm and security store fixtures, stone-working methods, and the gallery layout were inspected closely.

As stated above, the quarry was worked for two materials - firestone, and hearthstone. Provided that the quarry walls are in good condition, it is usually an easy matter to determine which material was being extracted. Firestone block extraction required careful separation of large square blocks from the working face. This leaves flat, well-picked walls and working faces, sometimes with the vestiges of slots carefully cut with picks along the sides and top of the face. The stone blocks were separated from the face by

the careful insertion of iron wedges along the base of the block to be released.

Hearthstone mining was performed with less precision, as only rough lumps of material were required. To advance the face when hearthstone mining, a slot was roughly cut along the top, sides, and sometimes base of the face, and wedges were used to break the lumps away. The walls are usually fracture surfaces with little evidence of tooling, save the bruising caused by steel wedges or chisels, used to prise away the lumps.

Both types of gallery are to be found in Carthorse Quarry, the firestone workings predominating. In places, it seems that both materials may have been worked at the same time, with careful tooling evident at the base of the face, and rougher work evident higher up.

The two quarrying/mining methods employed generated two distinct types of waste material. Certain horizons of the firestone bed are likely to have been considered inferior and were therefore put to one side. Where the material taken from the face broke as blocks too small to be sold, these lumps were also set aside. The rough dressing of the stone blocks before removal to the surface produced more quarry waste. Firestone waste, therefore, consists of slabs of inferior stone, irregular lumps up to 0.3 metre across, and smaller chippings and dust. This material was carefully stacked along the sides of working galleries, or used to completely fill disused roads within the quarry.

Almost all the material taken from the face could be used as hearthstone, with the exception of any lump containing a chert nodule. Hearthstone was used to whiten doorsteps and the like by rubbing a lump of it over the wet surface. The presence of a flint-hard lump of chert would do irreparable damage to the surface being treated. The chert in the Godstone quarries is generally restricted to a prominent band about 0.3 metres above floor level. Waste stacked in an area worked for hearthstone tends to be almost exclusively large lumps, each containing a chert band or nodule.

As most of the quarry's drystone walls have been painted, it is not always possible to determine the nature of the waste. However, since most of the gallery walls show evidence of careful tooling, it is a safe assumption that the bulk of Carthorse Quarry was excavated for firestone. The small amount of the quarry clearly worked solely for hearthstone is indicated on Fig. 5.

The layout of the galleries suggests that there were once two distinct entrances, and possibly originally two separate quarry workings, later connected to each other. One entrance is likely to have been in "The Devil's Hole", now beneath the warehouse, and the other, now lost, was probably in the bank to the west of the current entrance. This bank has probably been cut down to allow the present road to pass comfortably in front of the warehouse and eastwards towards Winders Hill. The conjectural routes of the original access galleries are shown on Fig. 6.

Within the quarry, the access route from the first entrance now stops just south of the ventilation shaft, and has been filled in. It may have linked with the most easterly section of Godstone Hill Quarry ("Main Series") before reaching the entrance pit. As already mentioned, that part of Godstone Hill Quarry was probably developed with Carthorse Quarry as a single working, and was later joined to "Main Series", which has a distinctly different style of working. What is now known as Carthorse Quarry was separated from "Main Series" by the infilling of connecting galleries, either during quarrying days, or possibly by mushroom cultivators as a way of controlling ventilation.

All routes from within the workings that head towards the now lost second entrance, stop short at roof falls. It is likely that the present entrance gallery was excavated to bypass this area of instability. An attempt to stabilise the original entrance is still evident in a few short sections close to the surface where brick and stone arching may be seen, which are possibly attempts to force a route through the collapsed section. The width of the vaulting is so narrow that it is hard to believe that it was constructed to permit anything more than men to pass through, and certainly not horses or trolleys loaded with stone.

The date of this vaulting is not known. One of the collapses, that at the southern end of the wet passage, has partially buried a length of D. C. electric cabling, indicating that this was in place before the collapse occurred. The same collapse, which may also be approached from the next gallery to the east, has also buried a water pipe leading out into the current main access gallery. All this indicates that access was possible beyond that particular roof fall for some years during the mushroom period, earlier this century. The 1935 plan shows the present entrance as being in use with no sign of the other entrance.

This suggests that the current entrance gallery was excavated or adapted from existing galleries during the early part of this century. It was certainly this entrance that was shown on the 1935 plan and used during the Second World

War. It is possible that the waste excavated when the new entrance was opened was dumped in and around the neighbouring mine to the east. This small mine has been almost completely back-filled with quarry waste, together with a certain amount of rubbish dating from the early 20th century. A tramway was shown on the 1910 Ordnance Survey plan running from near Carthorse Quarry into the entrance of the mine to the east, usually called "Winders Hill Mine" by today's mine historians. Was this tramway being used to fill in Winders Hill Mine? If soot, then the excavation of the present entrance to Carthorse Quarry did not take place until after 1910, assuming that there is a link between the two operations. Winders Hill Cottages were built on the line of the tramway in 1924.

In order to determine the period during which the gallery walls were painted, a close inspection of the walls was undertaken. This has revealed dated graffiti carved into the walls, which had subsequently been painted, and later dates cut through the paint-work. The most recent date discovered pre-dating the application of paint was 1933, and the oldest date cut through the paint was 1931. This corresponds well with the period at which mushroom cultivation is believed to have ceased.

It was also noticed that much of the wood-work installed to support the electric cabling throughout the site was fixed onto the walls with unpainted "shadows" visible, where the wood has rotted away. This suggests that the lighting was installed by mushroom growers, and was later adapted or replaced for use during the period of wartime storage.

Another graffito of interest is "LULU, 1919", under the paint, close to the current entrance. This is significant as the same inscription appears with other girls' names carved in the walls of Marden Quarry to the east, with the dates 1915-19. It is possible that these people were employed during the First World War in the mushroom farms as "Land Army" girls. In both quarries the second "9" of the "LULU" graffito is easily confused with a "2", thus - "1919". The juxtaposition of the 1915-19 dates in Marden Quarry suggests 1919 to be a more likely figure than 1912.

Water pipes were installed when the site was being used for mushroom growing, and these are still in place in a few areas, and where removed, the route taken by the piping can be determined by the positions of the hooks used to fix them to the walls and roof. Elsewhere, the course of the pipe can be seen as rust marks, or shadows on the roof. The route of the water piping is indicated in Fig. 7. A stand-pipe has survived close to the ventilation shaft.

It is clear that some alterations to the layout of the workings were made in order to make it more suitable for partitioning into discrete storage areas. The 1935 plan differs slightly from the newly-produced plan in that some galleries have been sealed, and one has been dug out. Where this has occurred, the sealed galleries are evident by the mixture of painted and unpainted blocks in the drystone walls retaining the blockage. In one place the blocks are mortared together to provide extra security. The alterations to the gallery plan are shown in Fig. 2.

Bat Survey

On February 3rd 1991, Mr Simon Mickleburgh of the Flora and Fauna Preservation Society was escorted into Carthorse Quarry to search for hibernating bats. None were found, although over the course of the winter at least three were seen during surveying visits. The high preponderance of crevices and other suitable hibernating sites render the chances of finding bats in the quarry quite low, unless they were present in reasonably high numbers. This very fact makes such sites ideal bat hibernaculae. The base of the ventilation shaft being blocked, the only known point of entry for bats is through the small hole in the entrance gate.

Conclusions and Recommendations

Carthorse Quarry is part of a firestone quarry operated at least since about 1700, which may have originally been called "The Devil's Hole Quarry". The site is probably the eastern half of this old quarry, the western half currently forming the extreme eastern section of the "Main Series", or Godstone Hill Quarry.

Earlier entrances to the quarry were located in "The Devil's Hole", a depression feature represented by the Ordnance Survey on the first edition plans of 1869, and in a bank some metres to the west of the present entrance. It is possible that the two earlier entrances represent access points to what were once two separate quarries, later merged into one operation. The current entrance is believed to have been excavated or adapted from existing galleries when an area close to the original eastern entrance became unstable, early in the twentieth century. The narrow nature of the new entrance suggests that it dates from a period of hearthstone extraction, or maybe mushroom cultivation.

Because casual visits to Carthorse Quarry have been discouraged for a number of years, the site has been well-preserved. The site is still largely in the same condition it was left in after the Second World War. Many of the lessons learnt in the quarry by careful inspection would not be so easy in the more frequently visited quarries of East Surrey.

Although much has been learnt about the site during these investigations, it is certain that there is still much more to be understood. As knowledge of the Surrey workings accumulates, more questions will need to be answered. Future visits to the site will help to provide answers to these as yet unasked questions.

Bats were observed in the quarry on a number of occasions. It is important that access for bats should be maintained, at least at the present level (through the hole in the gate). It is important to remember that, without the sanction of the Nature Conservancy Council (English Nature), it is illegal to prevent bats gaining access to established hibernating or roosting sites.

Improved ventilation would encourage more bats to use the quarry. This could not be achieved without unblocking the base of the existing ventilation shaft, and increasing the size of the opening at the entrance, thereby putting the security of the site at risk.

Although the stability of the site is good at present, deterioration may take place in the future, and occasional inspections are recommended to monitor the site for new falls, or extensions of the few existing falls.

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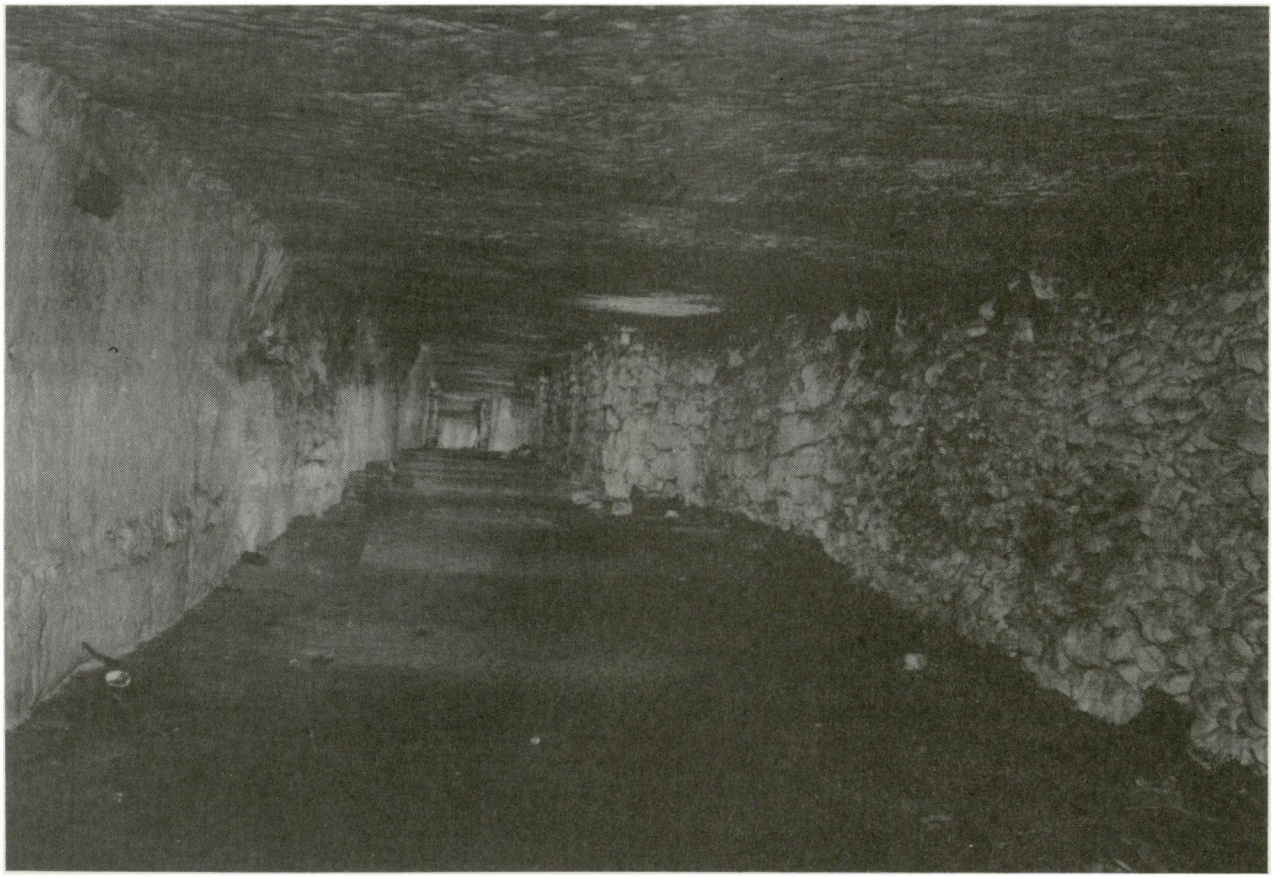
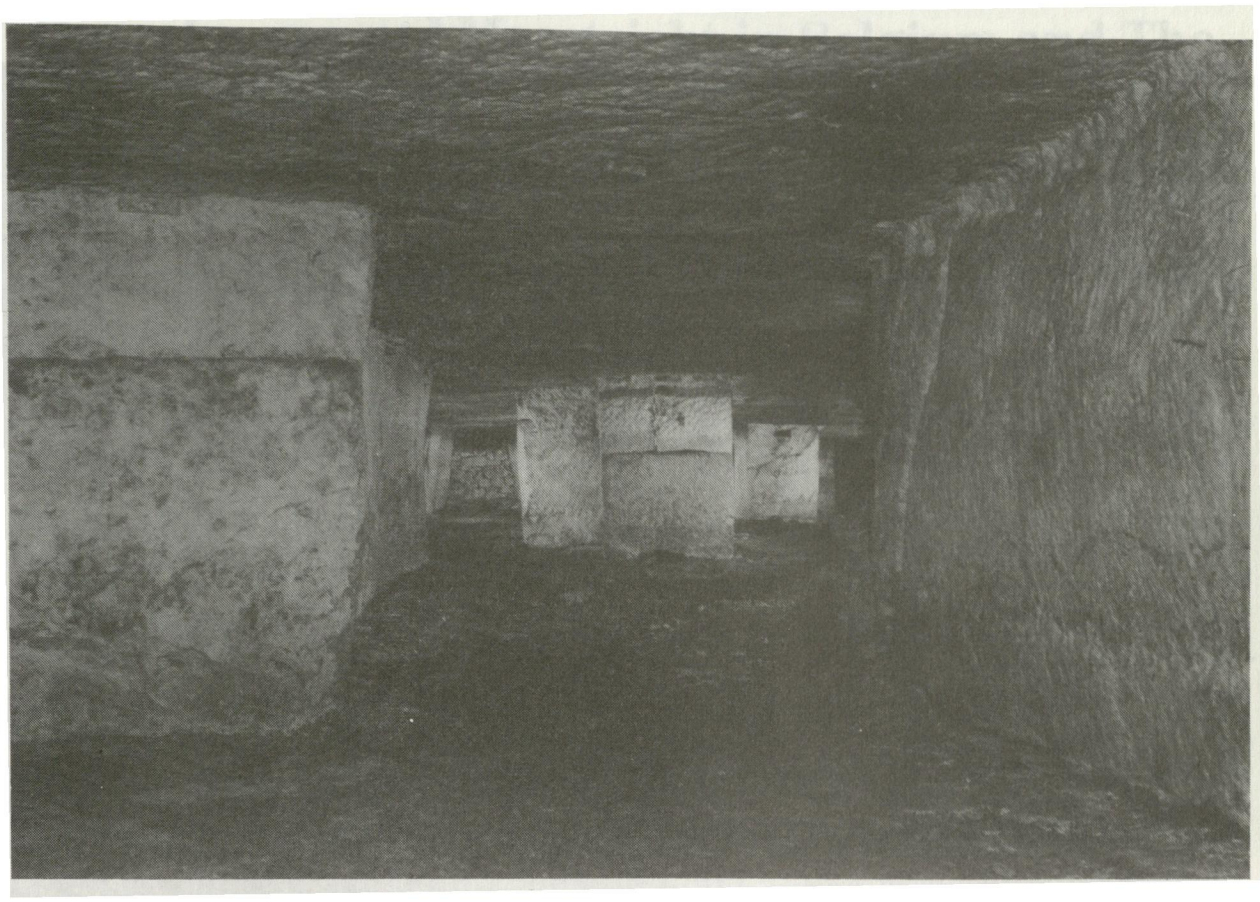
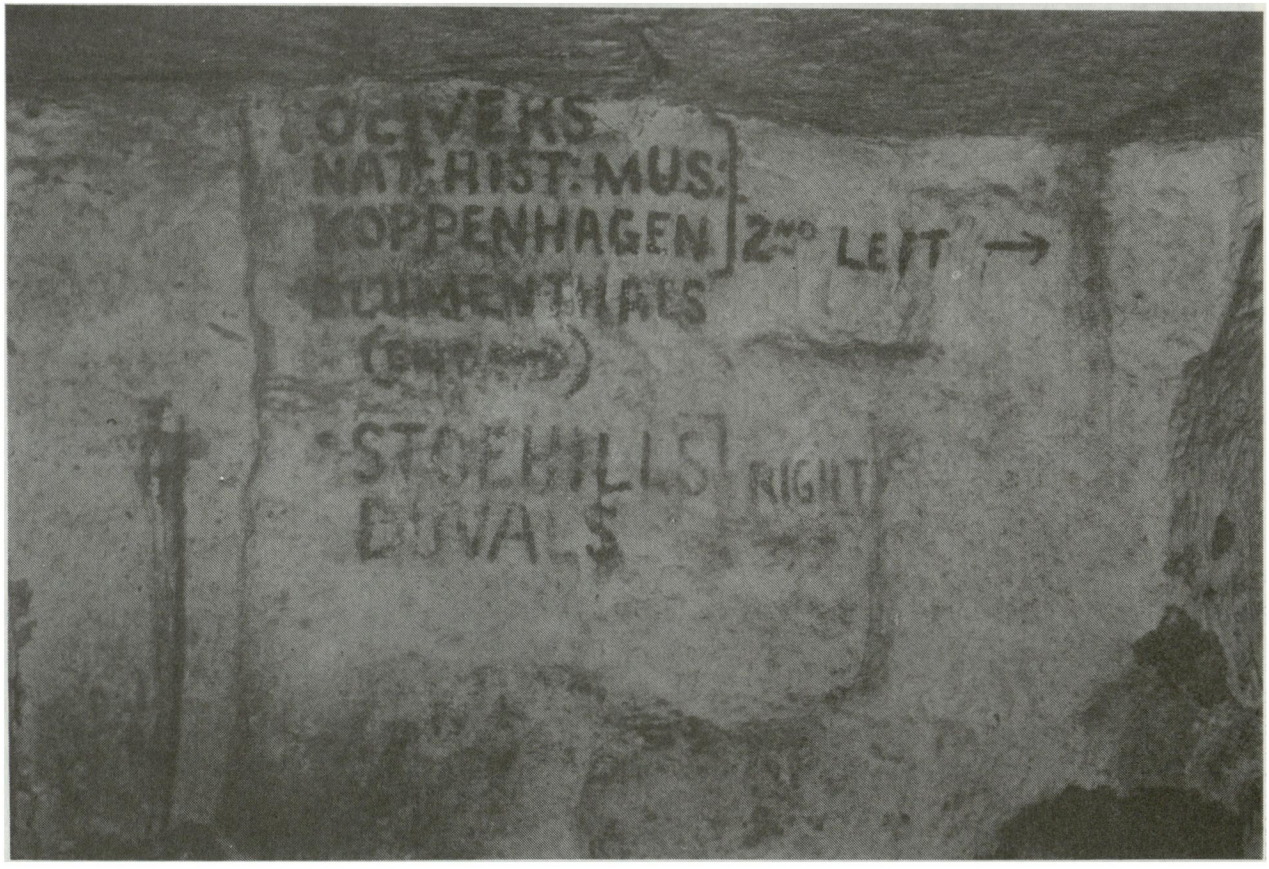
Reprinted from "Cave and Quarry" Issue 1 (Research and activity report of the Wealden Cave and Mine Society) with additional photographs by Nick Catford.






OLVERS
NAT. HIST. MUS.
KOPPENHAGEN
2ND LEFT →
STOCKHOLMS
RIGHT

The Secondary Use of Subterranean Limestone Quarries around Maastricht in Belgium and The Netherlands.

Ton Breuls – *Studiegroep onderaardse kalksteengroeven.*

In the area around Maastricht, stone has been quarried from the 13th century onwards. This stone quarrying produced a subterranean landscape of an impressive size. More than 250 quarries with the estimated total length of galleries of 600 km [400 miles].

The secondary use of the quarries, after the original stone cutting, has always been very intense. Many examples can be named – growing mushrooms, chicory and rhubarb: from shelters in wartime to the headquarters of NATO: from fleamarkets to potato storage. Subterranean tourism is very intensive and varied. Yearly, hundreds of thousands of people are shown around in seemingly endless galleries. Some quarries have been transformed to a cave aquarium, Roman catacombs or even a model coalmine.

Examples of small scale use are, for instance, the storage of coal samples from all over the world, the ripening of cheese or ham, a station for seismic research. Maybe the best variety of use is the next example, in one quarry the galleries are used as a basin for sewage water in another they are used as a wine cellar.

The manuring of acres with loose chalk was already known before the beginning of our era. We know so from Roman writers who already mentioned this.

That the Romans and their contemporaries have mined limestone underground, in proportions and in a way such as we know from past centuries, is highly unlikely. Although it is referred to persistently during tours for tourists or in publications, up till know they have never recovered tracks or proof of underground Roman activities. No more than activities that we can characterize as secondary use (the use of quarries after the limestone winning).

It is not until about the 13th century before we find information in old archives about limestone-use and -winning. In the quarries themselves unfortunately we cannot find anything about the absolute starting period. The oldest date known does not go back further than the second half of the 15th century, 1468. Not until the end of 1500, more dates are found in inscriptions and names on the walls. This timeless diary gives us a good insight into the secondary, later use of the quarries. The most important ones will pass in revue.

War and peace.

Up until the last World War Maastricht and the surrounding villages in Belgium and the Netherlands have been war territory exceptionally often. Because of the excellent North-South connection of the river Maas and the strategic position as protection of that water-way as a sally-port and as provision town the city was a wanted target. From the old chronicles and archives we know that the besiegers would settle their camps around the city in the near-by villages. The inhabitants of those villages were the first victims of the exacting and plundering soldiers and therefor sought the protection of the dark quarries with their cattle and possessions many times. Troughs and cattle stabling remind us of the underground stay of the animals. Bakingovens and sleep-niches refer to the human stay and the numerous drawn pictures of war-scenes and soldiers in strange dress ups outline the dreary pictures of the times upperground. During the last war the quarries functioned as a shelter during bombardments and fights. In a specially built strong-room, the valuable paintings from the Rijksmuseum were lodged, including the Nightwatch by Rembrandt. During the last few years of the war the Germans had advanced plans of installing factories for warindustry underground. The arrival of the allied armies made an end to this work.

During the last twenty years many atomic shelters have been built due to the cold war to accommodate thousands.

Until recently there was a well guarded NATO-commandpost and flight guidance centre in a limestone-quarry. The hypermodern equipment in the centuries old quarry have recently been transferred to a new concrete bunker in Germany.

Because of their forced stay underground during bad times, people learned the practical

possibilities of the quarries. Subsequently, they would also use the quarries in times of peace.

Cool in the summer and frost-proof in the winter so it was an excellent store for all kinds of field-fruits. Mangolds, potatoes, carrots and other products are still being stored by farmers in huge quantities. Near the entrance and as far as daylight reaches there are stables in which the animals could shade in the summer and find warmth in the winter. It has been done this way for centuries. Outside seeding- and harvesting time one can find ploughs, carts and other equipment in many quarries.

People also used to live there. Of course it was not the well-to-do people that would close up the front of a dead-end corridor with a wall, one hole for a door and one hole for a window. A hole in the ceiling was used as a chimney. Of the troglodyte-houses that were in use up until this century, a few have been restored and will be kept for posterity. Also hermits have found a home this way. Names as "Cluysberg" and "Aan de Cluys" speak for themselves.

Horticulture.

The quarries are very well known in the Netherlands and Belgium because of the mushroom growth. This form of horticulture has been introduced to our surroundings from France around the turn of century. Very soon it became a flourishing branch of industry with its climax in the years after the war. Almost every available meter was being used by mushroom-growers. After the sixties the underground cultivation deteriorated rapidly. From the about a hundred groweries in the quarries only one in the Netherlands and a few in Belgium remained. The activities were moved to modern upperground groweries. All that remains now are some old mushroom-beds, rusty pipes, crumbled cement floors, waterwells and ventilation shafts.

"Kardoen" is an almost forgotten vegetable, that used to be cultivated in the Sint Pietersberg. Hardly ânybody seems to remember what it looked or tasted like.

Chicory was cultivated at a small scale, only for personal use. A successful experiment with the underground growing of rhubarb was stopped. Disagreement about the use of the underground rooms and differences of opinion between the entrepreneurs led to the termination of this unique form of horticulture.

Winecellars and quarry-cheese.

The galleries - cut in limestone - meters below the surface, where temperature varies from 10 to 12 degrees Celsius in combination with a constant moistness are ideal storage where wines can mature independent of the seasonal influences under optimum circumstances. This has been known in France for ages, but on a modest scale it is also an old custom in the surroundings of Maastricht. Only recently there is a culinary primary: quarry cheese. The same ideal circumstances for storage of wine are ideal for the cheese. After maturing for 12 weeks the cheeses get their ideal taste in imitation of their famous French fellows. A test with the maturing of ham has been cut off recently. Although the quarry ham was of excellent quality, the sales did not go as well as expected.

Tourism.

The quarries of Maastricht and Valkenburg have been a major attraction for centuries, where strangers would come to from many places. From travel-stories we know that the first form of underground tourism took place long ago. Even famous persons included a visit to the limestone quarries in their travel plans. Philip II in 1550, the duke of Alva in 1570 and the duke of Parma in 1579 are the first of whom this high visit is known. To follow later on were Tsar Peter the Great and Napoleon. Of course members of the Royal Family visited the quarries frequently. Nowadays there is a broad choice of quarries that can be visited. During most guided tours the story of the limestone production is most important. During the years artists have been given the opportunity to perform their works of art in all forms on the wall. This however could cause the authentic look of the underground landscape to disappear. In many visitor quarries this has already happened. There are even quarries that have been furnished and rebuilt for a totally different presentation such as the quarry aquarium. Other names as coalmine, panorama-cave, Roman catacombs or Monstercave speak for themselves. Therefor we will have to handle that what has been left in its original state with extra care.

Markets and performances.

In a few places the underground landscape will function as a scenery for markets and fancy-fairs. The quarry in Kanne has a flea-market every Easter. Thousands of visitors from the frontier-area try to find a bargain by candle-light and the smell of hot-dogs. The "Gemeentegrot" in

Valkenburg has a similar attraction. In December there is a Christmas market for about ten days which has country-wide fame. Other quarries have the tradition of having night-masses or putting up christmas stables. Even concerts or festive receptions are constantly recurring events. And every year the quarries with its secretive galleries function as a scenery for various television or film recordings. A capricious quarrywall, with quarry-ruins and dark holes is in use as an open air theatre.

Various.

The enumeration of activities can be completed with some small scale project. In Geulhem people have moved coal to a limestone-quarry: the coalbank. This is a collection of hundreds of barrels of coal from every part of the world, pending a later comparable study they have been stored underground.

In Valkenburg there is a real family-vault in a quarry, where members of the Protestant community have found a final resting place. In the early days non-catholics were not allowed to be buried on sacred ground. That explains the somewhat gloomy underground burials. Various quarries are being used as a reservation at the moment. Provided with a decent gate it guarantees tranquility for thousands of hibernating bats. Maybe the last examples will show the contradictions best: part of the Sibbergroeve is being used as an basin for sewer-water and behind Chateau Neercanne the Kasteelgroeve serves as wine-cellar festive hall and reception area.

Subterranean Prague

Vaclav Cilek

Prague, the capital of the Bohemian kingdom, was built on a late Pleistocene river terrace, so no large underground structures could be formed. Instead, as a result of river flooding and gravel deposition, the oldest Romanesque buildings were buried three to five metres deep, so that now about 70 such buried structures give a unique view of the early city development. However, the list of underground sites in the city today amounts to almost 200, including underground water supplies, church crypts, military sites from the Gothic to the Second World War periods, underground sand mines, grottoes, and even natural caves and underground pseudokarst caverns.

PRAGA SUBTERRANEA
Prag, die Hauptstad des Königsreichs Bohmen, wurde auf der spät-pleistozan Fluss-Terrasse gebaut, deshalb sind keine grossen Höhlungen geformt worden. Aufgrund der Überschwemmungen wurden die ältesten romanischen Gebäude 3 – 5 m tief vergraben und so geben nun 70 solcher Bauwerke ein einmaliges Bild von der Frühentwicklung der Stadt. Es gibt heute jedoch fast 200 unterirdische Anlagen wie unterirdische Wasser-leitungen, Krypten, Militäran-lagen von der Gothic bis zum 2 Weltkrieg, unterirdische Bergwerke, Grotten, sogar natürliche Hohlen und pseudo-karst Höhlungen.

PRAGA SUBTERRANEA
Prague, capitale du royaume de la Boheme, fut construit sur la terrasse de cours d'eau de la fin du pleistocene, de sorte que de grands creux ne s'y formaient pas. Par contre, suivant des inondations, les plus vieux bâtiments romanesques furent ensevelis à trois ou cinq metres de profondeur, et de nos jours à peu près 70 édifices pareils nous offrent une image unique du développement primitif de la cité. Le total actuel de sites souterrains s'élève pourtant à presque 200, tels des canalisations d'eau, cryptes d'église, abris militaires de l'âge gothique jusqu'à la deuxième guerre mondiale, carrières a sable souterraines, grottes pittoresques, meme de grottes naturelles et cavernes pseudokarsts.

Prague, the capital of the old Bohemian kingdom, evolved in the 10th Century from dense but diffuse Neolithic, Bronze Age and Celtic settlements into an early Medieval town which soon became one of the three greatest European towns in the 14th Century.

The town was built on a late Pleistocene river terrace, so no large underground cavities could be constructed in the gravels. Instead, as a result of the river Vltava flooding, these deposits, from three to five metres thick, have buried and preserved some 70 Romanesque structures including the old Judith's Bridge, the Romanesque Palace of the Czech kings, and former churches which now form the crypts of later Gothic or Baroque churches. The most famous such structure, the pre-Romanesque crypt of St. Marguerrite's Abbey in Brevnov, has been dated 993 AD.

Other important subterranean structures are represented by adits constructed to tap springs from the Cretaceous aquifer, and to augment the City's water supply. The earliest adits were driven during the 12th Century, in the Strahov monastery, and in the 14th Century and later in the Castle. For example, in the Petřín and Strahov hills there are more than 20 adits with a total length of two kilometres; these still exist. The adits were often lengthened to increase their effectiveness, and the longest is now 365 metres. A similar system of adits in Střešovice, Veleslavín, and Bílá Hora establshed about 1540 supplied Prague Castle.

Emperor Rudolf II, in 1582 - 93, caused to be driven another remarkable adit, now known as Rudolf's passage, to take water from the river Vltava to his gardens in Stromovka. This beautifully made adit, 1102 metres long, was cut by hand from working faces at the bottoms of four shafts sunk from the hilltop above. It still serves its original purpose.

There are several grottoes in Prague. The most famous are the Renaissance grotto in the Valdstein palace, and the romantic 19th Century grotto called Grébovka in Havlíček's gardens.

The Baroque and Anti-Reformation movement produced a number of large Baroque churches, must of which conceal larger or smaller crypts. Examples are St. Trinity Church in Spálená Street, St. Francis' Church and St. Havel's Church in the Old City. But the most striking crypt, with inhumations, lies beneath the Carmelite Church of the Child Jesus in the Lesser City. Josef II prohibited burials inside city walls, and ordered the burials to take place

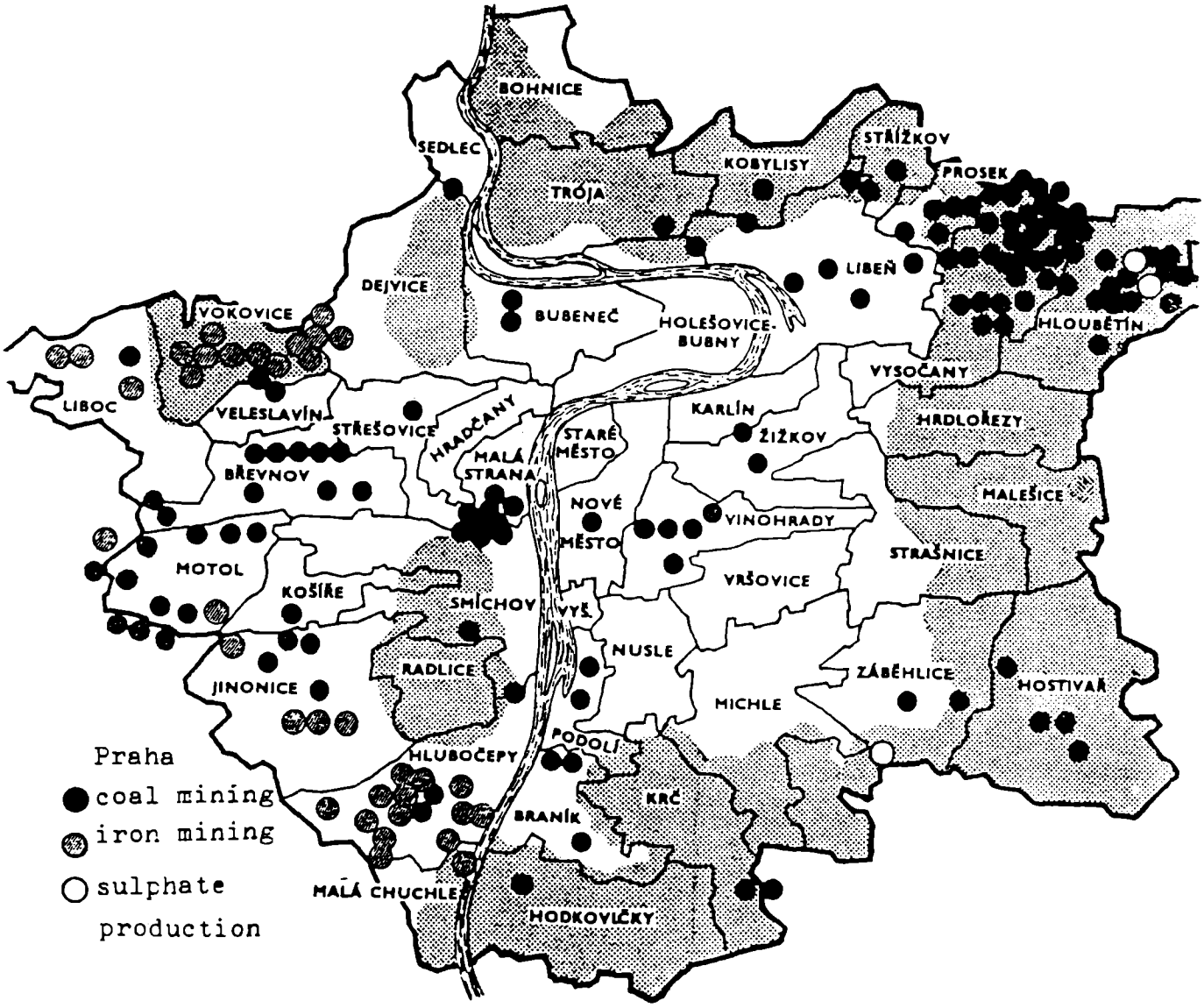
in cemeteries, but it is believed that some crypts were 'excluded' from this edict simply by enclosing them within their own walls.

Underground sand mines occur in Cretaceous sandstones at Strahov, Břevnov, Střešovice hills, and on the margins of the Prosek and Hloubětín plains. The principal material extracted was a soft white kaolinitic sand used for stucco and casting. The labyrinth of the former five to seven kilometres of passages which existed under Prosek is now reduced, by frequent collapses, to a few isolated small networks of tunnels each of a maximum of 500 metres in length. The remains of Cretaceous coal and Ordovician sedimentary iron ore mines can be found in Petřín and Hloubětín (coal) and in Červený, Vrch, Jenerálka, and Troja (iron.)

The underground military structures of Prague were developed during the construction of the huge Baroque brick fortress walls which encircle the whole city. Casemates can be found in Vyšehrad, Hládkov, Strahov, and Kramář's villa. Military hideouts were constructed before the Second World War; and later ones under German rule in 1943 – 44 in Hloubětín, Bráník quarry, and elsewhere. Some of them were still in use after the war.

The Bohemian karst (limestone) extends into Prague, and some 30 small natural caves are known to exist. The largest one, St. Procopius' Cave, was some 120 metres long; a famous archaeological site and place of pilgrimage, it was destroyed by quarrying last Century.

The pseudokarst is represented in Prague by narrow gulls in sandstones – fissures widened by cambering on steep slopes. A strange cave, six metres by two metres by two metres, covered internally with quartz crystals weighing up to 3.5 kilograms each, was discovered, and destroyed, in 1883; it was located in Proterozoic graphitic quartzites and destroyed by quarrying.



The Icelandic souterrains: A survey

Gudmundur J. Gudmundsson

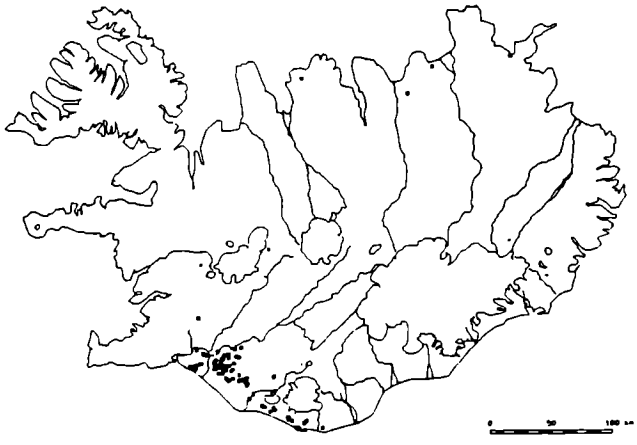
Most of the Icelandic souterrains are dug into post-glacial dunes made of sandstone or tuff. Except for a handful, all of them are in the southern part of the country. The oldest are believed to be from the early 10th century, shortly after the Scandinavian settlers came to Iceland. There are theories that Irish hermits, living in Iceland before the Scandinavians, built some of the souterrains, but these theories have not been substantiated. The souterrains have been used as barns, to house cattle, sheep, and later vegetables. There is a variety of graffiti on the walls, the oldest being from the 18th century. Quite a few of the souterrains are still in use, but these are becoming fewer and fewer every year.

DIE ISLANDISCHEN ERDSTALLE: EIN GUTACHTEN

Die meisten der islandischen Erdstalle sind in nacheiszeitliche Dünen gegraben, die aus Sandstein oder Tuff (vulkanisches Gestein) bestehen. Mit Ausnahme von ein paar Vereinzelten, liegen sie alle im Süden des Landes. Die Altesten sind schatzungsweise von Aufang des 10. Jahrhunderts, kurz nachdem die skandinavischen Siedler nach Island kamen. Es bestehen Theorien, dass Irische Einsiedler, die bevor den skandinaviern in Island lebten, einige der Erdstalle gebaut haben sollen, aber diese Theorien sind noch nicht erhartet. Die Erdstalle sind als Scheunen benutzt worden, um Kühe, Schafe und später Gemüse Unterzubringen. Es gibt verschiedene Graffiti an den Wanden, die ältesten vom 18. Jahrhundert. Eine gauze Ausahl der Erdstalle sind noch in Gebrauch, aber diese werden immer weniger.

UN RELEVE DES SOUTERRAINS D'ISLANDE

La plupart des souterrains d'Islande sont creusés dans les dunes poste-glacières composées de grès ou de tuf. A de rares exceptions près, tous se trouvent au sud du pays. Les plus vieux datent, semble-t'il, du début du 10e siècle, peu après l'arrivée des colons scandinaves en Islande. La théorie selon laquelle les ermites irlandais, habitants de l'Islande avant les Scandinaves, avaient áménegé quelques-uns de ces souterrains, n'a pas été établie. On a utilisé les souterrains en granges, pour protéger le bétail, les moutons et, plus tard, le légumes. Il y a, sur les parois, divers graffiti, dont quelques-uns datent du 18e siecle. Plusieurs souterrains son encore en service, mais ceux-ci se rarefient.



Most of the Icelandic souterrains are in the southern part of the country (see map) Only three examples are known from the north, none from the east or west. The distribution is limited by the material they are made in. Most are dug into post-glacial sandstone dunes, but a few are in tuff.

Age

The oldest souterrains were probably made shortly after the first nordic settlement in the late 9th Century. The youngest are from the period 1939 - 1940.

It is very difficult to determine the exact age of each souterrain. The sandstone is soft so that graffiti are easily erased, especially as most of the souterrains have been used constantly for centuries. Most of the graffiti now visible are from the 19th and 20th centuries even though the souterrains can be much older, for example from the Middle Ages.

The safest way to determine the minimum age is of course by written sources, if they exist. Another possibility is the tephrochronological method, that is by examining tephra (volcanic ash) layers in the vicinity of the souterrains, especially ruins, refuse dumps or anything else connected with them. One of the problems concerning age determination is that some of the souterrains have been in continuous use for several hundred years. Some parts of them might be from the Middle Ages but others from the 20th Century.

The oldest definite information we have on Icelandic souterrains is in a book from the early 12th Century containing records of miraculous incidents connected with the first Icelandic saint. This souterrain is now in ruins. Documents from the 13th and 14th Centuries mention the farms at Hellur á Landi in Rangárvallasýsla and Eystri and Vestri Hellur in Arnessýsla. In the Icelandic language there is no distinction between souterrains or natural caves, both are called hellir, so the meaning of the names of each of these farms is 'cave' or, in this case, souterrain so there must have been souterrains there in the Middle Ages as there are now. Whether they are the same souterrains is difficult to say but we think so. The souterrains Traðarholtshellir and Kolsholtshellishellir are also definitely from the Middle Ages; this has been established by tephrochronology (using volcanic ash layers from eruptions dated in the historical record or by radio-carbon dating) (Fig. 1)

Size

Most of the souterrains are small, 10 - 20 m long, 5 - 8 m wide and maybe 2 m high, but a few are quite large. The largest one is at Hellur á Landi over 50 m long and parts of it more then 4 m high. (Fig. 2.) From the late 17th Century until the middle of the 19th Century it was the largest 'building' in Iceland. Other large souterrains

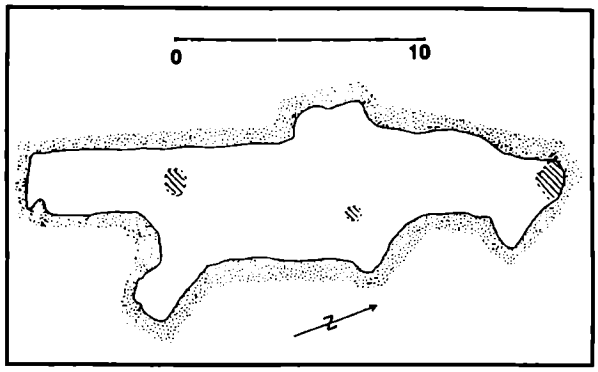


Fig. 1. The souterrain at Traðarholt: Certainly one of the oldest souterrains in Iceland.

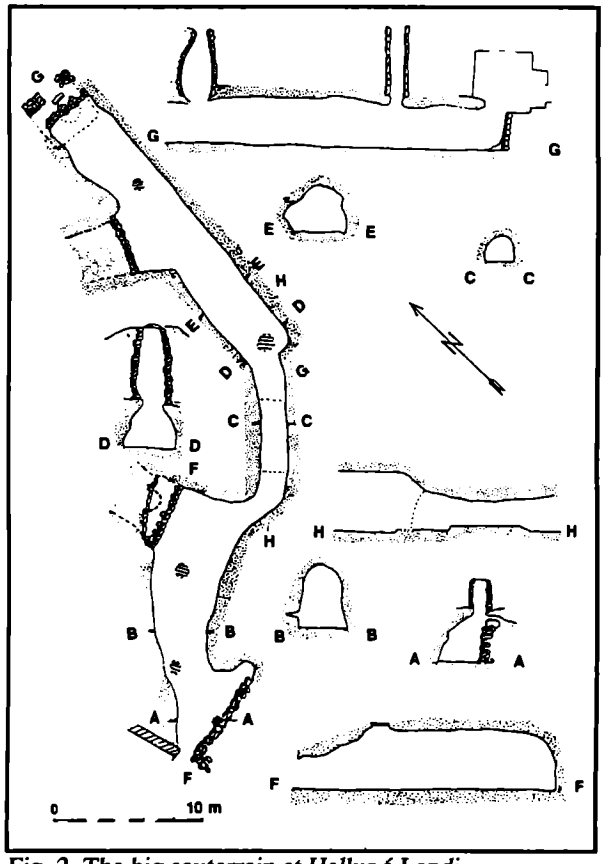


Fig. 2. The big souterrain at Hellur á Landi.

are at Efri-Gegnishólar in Arnessýsla and at Ægissíða, Rútshellir and Steinahellir in Rangárvallasýsla.

Building method and shape

There are three basic methods of making a souterrain. The commonest one is to dig a tunnel into the side of a sandstone dune. Another method is to dig a shaft into the top of the dune and, when this is deep enough, tunnelling horizontally. Quite a few souterrains have also been dug into sandstone cliffs in gullies.

The souterrains vary a great deal in shape. Most common is a rectangular section tunnel with a vaulted ceiling, but rounded sections with corbelled roofs are also common. Some have annexes from the main tunnel and occasionally there are clusters of caves around the main tunnel. (Fig. 3.)

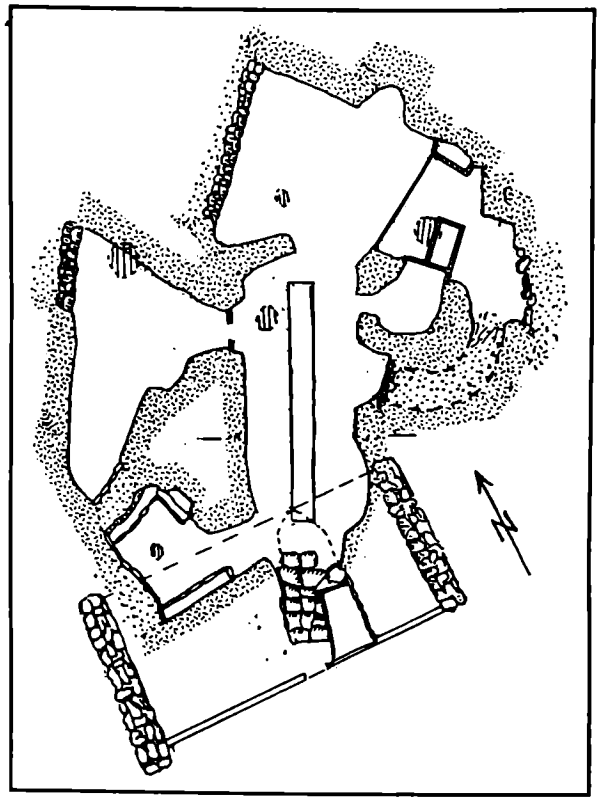


Fig. 3. The souterrain at Þjóðólfshagi.

Most of the souterrains, no matter what their size or shape, have one feature in common and that is a ventilation shaft in the ceiling. Usually the shaft is narrow but there are examples of shafts so big that they were used to store hay. A good example of this is the shaft at Þorleifsstaðahellir in Rangárvallasýsla. (Fig. 4)

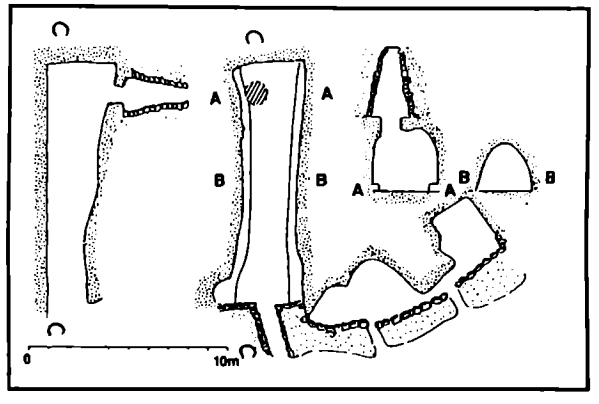


Fig. 4. The souterrain at Þorleifsstaðir.

In front of the entrance there is usually a small building called the 'forskáli' (entrance shed). The walls of this were usually of stone and turf but in recent years of concrete. The roof is made of timber and corrugated iron. The roof on very old entrance sheds may be of timber, thin stone slabs and turf. Several souterrains are connected with other buildings, often barns, stables or cowsheds but occasionally living quarters.

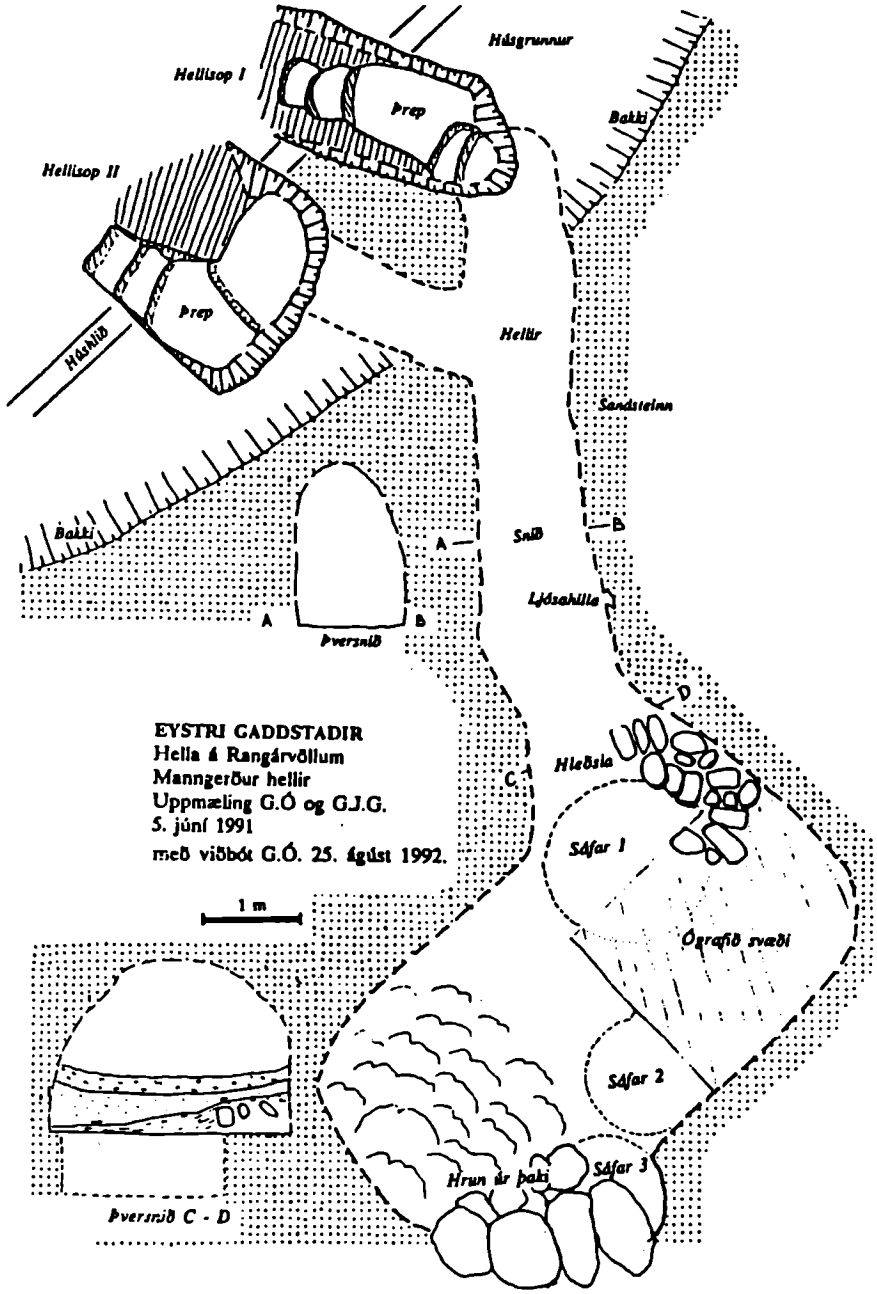
How Icelanders used the souterrains

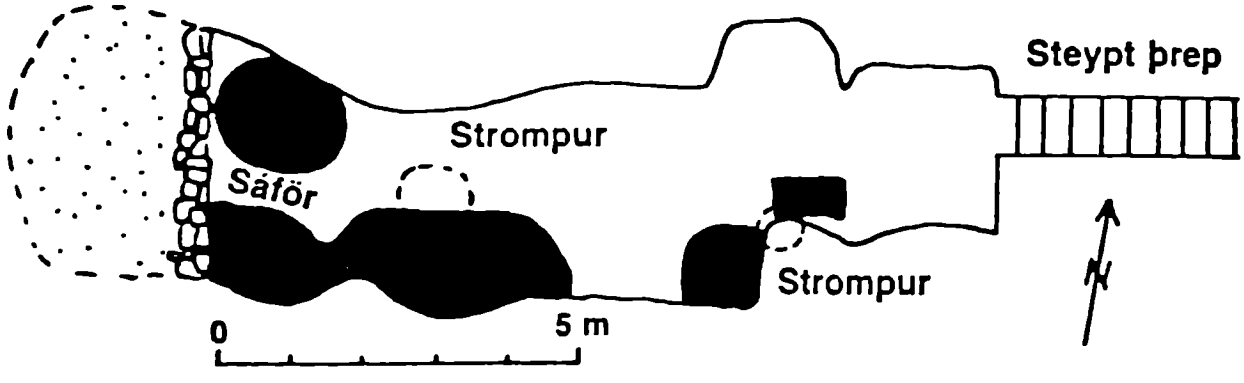
From the beginning the Icelandic souterrains were used as any other outhouses on the farms. Most of them were

used to shelter sheep and if they were big enough they were also used as barns. In the Middle Ages some of the biggest ones were used as cowsheds, for example the oldest one we know of at Oddi in Rangárvallasýsla. Some were used as stables.

After the introduction of the potato in the 18th Century many souterrains were changed so they would be better suited for storing potatoes and turnips. The souterrains are in general excellent for storing food, being dark, cold and dry. Farmers have also told me that some are better for storing potatoes, and some better for storing turnips, but they have no explanation for this - the souterrains look identical. Two souterrains were purposely built as pantries (Ægissíða in Rangárvallasýsla and a newly found souterrain at Eystri-Gaddstaðir.) In the floor are still marks left by large wooden barrels that the Icelanders used for storing food. (Fig. 5.)

Fig. 5. Top – the pantry at Eystri-Gaddstaðir and bottom – the pantry at Ægissíða





At least one souterrain in the north (Skagafjarðarsýsla) was built as a forge and there is some indication that the annexe of Rútshellir was also a forge but more about that below. Very few were used as living quarters and I don't think any of them were built especially for that purpose. Only one was used-so permanently, the souterrain at Laugarvatnsvellir, in the first two decades of the 20th Century. (Fig. 6.) Some were used as temporary shelters when farms were being rebuilt. Occasionally paupers, tramps and misfits lived in souterrains for short periods. Part of the souterrain at Kolsholtshellir in Arnessýsla was used as a kitchen in the late Middle Ages and in the front was a cow-house.

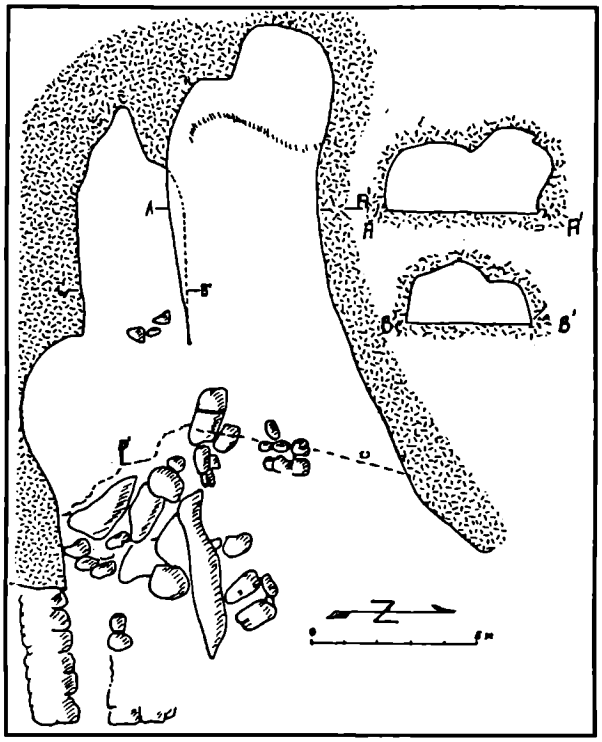


Fig. 6. The souterrain Laugarvatnsvellir. On two occasions people tried to settle here in the first decades of the twentieth century.

In the late 19th Century some carpenters used Moldarhellir in Skaftafellssýsla as a shelter while they were building a boat. County meetings were held in some of the biggest souterrains in the 19th and early 20th Centuries. No other houses were big enough for that purpose.

Graffiti

Most of the graffiti that decorates the walls of the souterrains is quite unremarkable, mostly children's initials from the 19th and 20th Centuries. Older initials are of some interest but they are rare for reasons I have already explained. We have tried to find information about as many as possible of the people that carved their names on the walls especially, the owners of the older initials, but without much success.

The most interesting graffiti are the numerous crosses. Most are small, simple, and of little interest; but several are so big and elaborate that whoever made them must have been doing it for a special purpose. The biggest one is in the souterrain at Efri-Gegnishólar in Arnessýsla. There are three crosses in all on the wall, the biggest one is 98 cm high and 61 cm wide. On each side there are much smaller crosses, around 20 cm high; the one on the left is badly damaged. In the souterrain at Arbæjarhellir in Rangárvallasysla are similar crosses but smaller, the biggest around 16 cm high and 12 cm wide, the smaller around 8 cm. The small cross on the left is also damaged. (Fig. 7.)

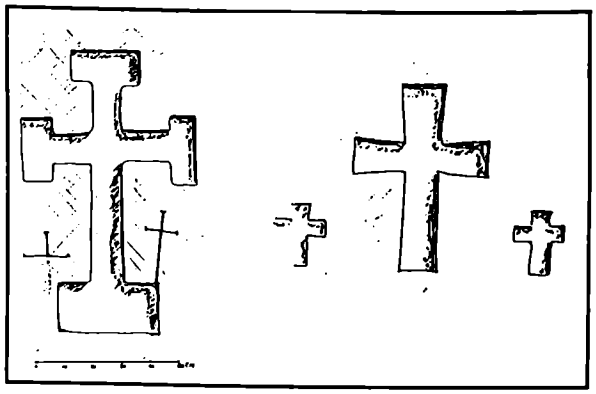


Fig. 7. The big cross at Efri-Gegnishólar on the left. The crosses at Arbæjarhellir on the right

These crosses represent, of course, the crucifixion and we think that the damaged cross on the left represents the thief that mocked Christ. As for who made the crosses and why we don't know. Some people think Irish hermits did it, years before the Nordic settlers came, but there is no proof of that. We think it more plausible that those souterrains were used by Catholics after the reformation, but there is no proof of that either.

The walls of the souterrains at Seljaland in Rangárvallasýsla are almost covered with crosses of all kinds. (Fig. 8.) There are Greek and Latin crosses, and at least two patriarch crosses and a procession cross. The most remarkable in my opinion is the one that can be illuminated with a candle.

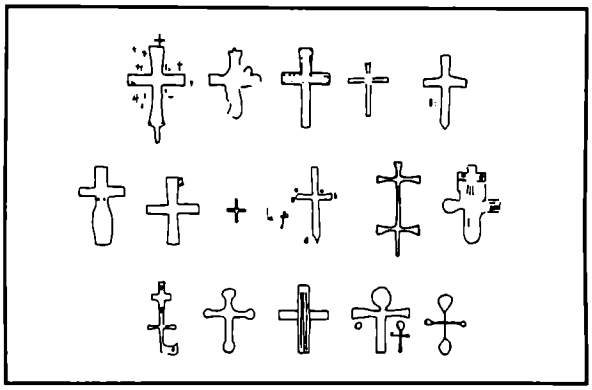


Fig. 8. A few of the crosses on the walls of the souterrain at Seljaland

Few runic inscriptions have been found, and most of them are completely incomprehensible. There were many runes at the big souterrain at As in Rangárvallasýsla but the souterrain was broken down in the 1930s so we have only some sketches drawn by an artist a few years earlier to work on. On the same farm there are many ather souterrains and in one of them is a large runic inscription. The same goes for the runes in the souterrain at Þórunúpur in Rangárvallasýsla, all are incomprehensible. At Litlu-Tungu in Rangárvallasysla the name Hildur has been craved on a souterrain wall.

Hildur means a valkyrie. There are a few others but they are just single runes. (Fig. 9.)

Fig. 9. The runes at Þórunúpshellir.

Irish hermits' caves, Wodan's temples, or just barns and stables?

The most persistent theory on the origin of the souterrains is that some of them were originally made by the Irish hermits that lived in Iceland before the Scandinavians. For almost 100 years scholars and laymen have argued about this theory. However, we have no evidence either for or against. Several people have claimed to find graffiti connected with the hermits, but either the graffiti have vanished or they were never there in the first place. It is also very easy to misunderstand the vague graffiti on the walls of a dark souterrain, especially with a poor light.

The crosses I mentioned earlier don't prove anything either, even though crosses of this type are unknown in Scandinavia (but 12 examples have been found in Ireland.) On the other hand, we know from the sagas that the Icelanders had information on the Irish souterrains at least in the 13th and 14th Century. In the Book of Settlement, (Landnámabók.) there is a story of one of the earliest settlers who went on a Viking raid to Ireland before settling in Iceland. He broke into a souterrain, killed one of it´s defenders, and took his sword and great treasures.

A similar tale is in Orvar-Odds´ saga. In a Viking raid on Ireland Oddur broke into a souterrain where four women were hiding . Oddur was also involved in killing bandits in a souterrain in Aquitaine (France.) Both of these tales confirm Richard Warner's theory in his articles in Archaeologia Atlantica Vol. 3. and in Harriet Crawford's 'Subterranean Britain', that the Irish souterrains were built for defensive purposes or as hiding places. They also show that the Icelanders knew of the Irish and Aquitanian souterrains but they are no proof that the souterrains were made by Irish hermits. The most plausible theory of course is that the Icelanders started to dig their souterrains because they had suitable ground, the sandstone.

In 1936 two Germans Dr. Walter Gehl and Paul Burkert came to Iceland on an archaeological expedition. Gehl was a respected scholar but Burkert was a crank. He was a member of the SS and much involved with Himler. He had financial support from the academically dubious SS academy Ahnenerbe. Among the sites they explored was Rútshellir. After a short investigation they thought they had found a heathen temple. Burkert sent a report to Ahnenerbe on this discovery and Gehl wrote an article in a learned journal. Ahnenerbe discredited Burkert's report and a little later he was expelled from the SS for embezzlement.

As I have mentioned, the Icelanders had a more prosaic explanation of the inventory in Rútshellir, and personally I think they were right. But on the other hand Gehl might be on the right track. Only archaeological research can decide. (Fig. 10.)

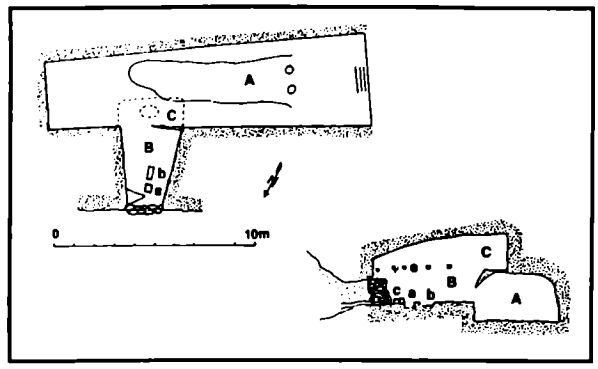


Fig. 10. Rútshellir. Gehl and Burkert thought that the smaller room was the sacrificial chamber, and the triangular stone a sacrificial altar.

Preservation

The best way to preserve the souterrains is of course to continue to use them as they have been used for centuries. While they are in use they are kept in good repair and locked during the winter, so snow and frost can't damage them. Sudden changes in temperature are the souterrains' worst enemies. Of course some have been destroyed on purpose but most are ruined by neglect. A few important souterrains are in grave danger, for example Skollhólahellir at As in Rangárvallasýsla (the one with the runic inscription). The same goes for Rútshellir and the biggest souterrain at Ægissíða. Some farmers are proud of their souterrains, even if they don't use them any more. A good example of these are the souterrains at Arbæjarhellir and Hellir á Landi in Rangárvallasýsla.

Editorial Note

An admirable and fully illustrated treatment of the Icelandic souterrains can be found in the Icelandic book *Manngerdir hellar á Íslandi* [Man-made caves in Iceland], of which Guðmundur J. Guðmundsson is a co-author:

All the diagrams were drawn by Arni Hjartarson, Guðmundur J. Guðmundsson and Hallgerður Gísladóttir, except no. 5. which is drawn by Guðmundur Ólafsson and Guðmundur J. Guðmundsson and no. 10 which is drawn by Walter Gehl and Frank Burkert.

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